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GEOLOGIC TEMPERATURE RECORDERS

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Introduction

A QUANTITATIVE knowledge of the conditions of formation of minerals and rocks—the temperatures, pressures and concentrations involved—is naturally a matter of much concern to the geologist. At times he is able to view certain processes of mineral formation in progress and can make direct measurements of some of the conditions with the aid of the various devices that have been developed for such purposes, usually by workers in other branches of science or technology. For the measurement of temperature, which is the variable here under discussion, a great many devices are available but they uniformly depend upon one broad principle. The known rate of change with temperature of some property of a substance—volume, electromotive potential, radiation—serves as a measure of temperature. Various instruments for the direct measurement of temperature have been used by the geologist with the result that he has come to know something of the temperatures of flowing lavas, of fumaroles, of hot springs and of other geologic activities taking place at yet more moderate temperatures.

It is not to direct measurements made upon materials in process of change that attention is here directed. For measurements in connection with many technological or natural processes it may be inconvenient to have an observer continuously present, but it has proved possible to construct instruments which will furnish information as to the temperature. These vary from elaborate recorders which provide a complete, continuous record of the temperature, to the other extreme of maximum or minimum thermometers which furnish only information as to the maximum or minimum temperature attained. In reality they are, just as definitely, recorders. It need hardly be said that, whether of the elaborate type or of the simplest type, recorders depend for their use upon a foreknowledge of the change of some property with temperature. The simple maximum or minimum thermometer merely records the maximum extent of this change in the one direction or the other. In this respect geologic temperature recorders are of the same character as the simplest type of recording instrument, but in other respects they are very different, indeed they are not instruments at all.

It is manifestly not merely inconvenient but altogether impossible for the geologist to be present during most geologic processes, especially those that took place in the remote past. Any record of temperature will, for these completed processes, be obtained, not by direct observation nor yet through the agency of

any man-made recording device, but rather by seeking in the rocks themselves internal evidence of the temperatures that have existed. Such evidence must come from ascertained facts regarding the effect of temperature upon various physical properties of the minerals of the rock and upon physico-chemical properties of the mineral assemblages. *Minerals are the geologic temperature recorders.*

Nearly all man-made devices for determining temperature depend upon the measurement of some property which varies *continuously* with temperature. Occasionally it is possible to use some such property in the estimation of geologic temperatures. Thus, the change of volume which has occurred during the cooling of liquid inclusions in crystals, as determined by the relative volume of liquid and its associated gas bubble, has been taken, under certain assumptions, as a measure of the drop in temperature, from which the temperature of envelopment of the liquid by the crystal is readily obtained. Likewise the change of solubility of certain salts precipitated from such fluid inclusions, as determined by the relative quantity of salt and solution, may be a measure of the fall in temperature. Estimates of temperature based upon such considerations have but little reliability. They involve too much unverified assumption as to the initial condition of the materials and too little exact knowledge of the temperature coefficients of volume and solubility of such materials.

It is rather to *discontinuous* changes of properties consequent upon change of temperature that we must turn for indications of temperature in geologic processes. The discontinuous changes are those which ordinarily accompany "change of phase," such as melting, boiling, inversion and others. There is, of course, nothing novel in such procedure. In ordinary thermometry use is made of these discontinuities of properties accompanying change of phase; indeed, the whole thermometer scale is referred to a number of fixed points, the melting-point of water, the boiling-point of water, the boiling-point of sulfur, and so forth. The devices depending upon *continuous* changes of properties serve only to furnish arbitrary subdivision of the intervals between these fixed points. Geologic thermometry is, therefore, fundamentally of the same character as ordinary themometry; both use as reference points the temperatures of phase changes. In ordinary thermometry it is possible to choose convenient and well-behaved substances for those whose phase changes are to constitute the fixed points. But the geologist, having no such choice, is at a decided disadvantage. His temperatures must be referred to possible phase changes in the substances actually present in rocks. In addition there is, in geologic thermometry, no means of subdividing the intervals between the fixed points. The intervals should therefore be as small as possible. Ideally, the geologist should know the temperatures of all the phase changes of all minerals. Although this goal is far from attainment, such knowledge is being gradually accumulated through laboratory studies of the so-called thermal properties of minerals.

What a happy circumstance it would be for the geologist if the melting, inversion and boiling phenomena of a substance were really adequately described by the designation *thermal properties.* Unfortunately, they are *thermodynamic* properties. In all these changes there is involved, in addition to a thermal factor, a work factor, because a change of volume accompanies the change of phase, and the magnitude of the work factor depends upon the applied pressure. The temperature at which the phase change occurs therefore varies with the pressure, the effect of pressure being expressed

quantitatively in the well-known Clausius-Clapeyron equation. The variation is a matter of small concern to the physicist seeking to establish a series of fixed points on a thermometer scale, for he can define a point in terms of an arbitrary and convenient pressure, whereupon the temperature of the phase change becomes indeed a fixed point. But the geologist must take things as he finds them. He has no control over the process whereby minerals were produced, and in seeking to use the temperature of a change of phase as a "point" on a thermometer scale he must have due regard for the effect of pressure on the temperature at which the change occurs. It is sometimes possible to estimate with sufficient accuracy the superincumbent load under which mineral formation or transformation occurred, and thus to make appropriate correction to the temperature as measured under the ordinary pressure, but it is always desirable to place principal reliance upon phase changes in which the volume change is small and the effect of pressure correspondingly small. Thus equilibria between solids or between solids and liquids are generally to be preferred to equilibria involving the formation of a gas.

Having gained, by laboratory investigations, a knowledge of temperatures of various equilibrium phase changes for a wide range of mineral substances and having thus established his "fixed" points, the geologist puts them to work by examining rocks and attempting to decide from internal evidence whether its materials have passed through any of these points. The nature of the evidence varies and can only be discussed in terms of specific examples. It is always concerned with the answer to the question whether or not a certain temperature has been attained and thus is, as already pointed out, not unlike the evidence furnished by a maximum (sometimes a minimum) thermometer. With this preliminary discussion of the general character of natural temperature recorders in geology, we may pass to a consideration of some of the "fixed" points and their utility.

Melting-points

The melting-point of any crystalline substance, at a given pressure, places an upper limit upon the temperature range in which that substance can crystallize at that pressure. To be sure, this is frequently not a particularly useful fact, for the presence of other substances usually lowers the melting-point so much that the limitation placed by the melting-point of the substance itself is altogether too wide, especially for substances of high melting-points. If we consider Table I, in which are given significant melting-points of minerals, we find that there is evidence from other considerations that such minerals as olivine have crystallized in all rocks at temperatures far below their melting temperatures, so far indeed that the melting-point is only of secondary importance as an indicator of the maximum possible temperature at which crystallization could have occurred. On the other hand, if we turn to such a mineral as native bismuth, which melts at 271° at the ordinary pressure,[1] we may say that in any deposit containing that mineral we may be sure that the bismuth and any minerals deposited contemporaneously were formed (crystallized) below 271°, and this may be very useful.

The limited utility of the minerals of high melting-point as indicators of maximum possible temperatures of their crystallization no longer obtains, of course, if the magnitude of the effects of the associated minerals is known.

[1] Bismuth, like ordinary ice and unlike most substances, contracts on melting and its melting-point is consequently lowered by increased pressure. At 3,000 atmospheres, corresponding with a depth of some 10 kilometers in the earth, it is lowered only to 260°.

TABLE I

SIGNIFICANT MELTING POINTS OF MINERALS

Olivine (forsterite)	Mg_2SiO_4	1890	Pyrrhotite	$FeS + S$	1157–1187
Enstatite	$MgSiO_3$	1557*	Galena	PbS	1120
Plagioclase (An)	$CaAl_2Si_2O_8$	1550	Argentite	Ag_2S	842
Diopside	$CaMgSi_2O_6$	1391	Stibnite	Sb_2S_3	546
Plagioclase (Ab_1 An_1)		1287–1450	Pyrargyrite	$3Ag_2S \cdot Sb_2S_3$	483
Orthoclase	$KAlSi_3O_8$	1170*	Orpiment	As_2S_3	320
Plagioclase (Ab)	$NaAlSi_3O_8$	1120	Bismuth	Bi	271
Aegirite	$NaFeSi_2O_6$	990*	Sulfur	S	119

* Minerals so marked melt incongruently.

In other words, if we know the melting-temperatures and general thermal behavior of mineral assemblages, then the properties of the assemblages can be used in the same manner as the properties of individual minerals, and lower limits can be set to the maximum possible temperature of crystallization. An enormous amount of information is, indeed, now available upon the melting-points of mineral mixtures and is used to indicate maximum possible temperatures of formation. It is not possible to present such material in brief compass, and in its details it concerns primarily the geologist rather than the physicist, who can in this connection be interested, for the most part, only in methodology.

Upon occasion the geologist may wish to know not merely the temperature at which a certain mineral or group of minerals formed, but also the temperature that may have been attained by the liquid or melt from which they formed. Information as to the temperature attained when the melt was (if it ever was) at very great depth in the earth, we may not hope to secure, but upon its temperature when it reached the position in which we now find its products we can reach rather definite conclusions. They come again from consideration of melting-points of minerals, not, to be sure, of the minerals formed from the melt, but of the minerals in foreign inclusions that have been caught up by the melt. Small inclusions must attain the full temperature of the liquid and show the appropriate effects. Solution there frequently is, but forthright melting is not common and is displayed only by inclusions made up of the more fusible minerals or mineral assemblages. The evidence points strongly toward the conclusion that the liquids or melts were not excessively hot, were, indeed, in most instances within their crystallization range.

Besides indicating the maximum possible temperature of crystallization of a mineral, the melting-point may be regarded also as the minimum possible temperature of existence of a liquid having the composition of the mineral. However, when we find a rock giving every evidence of having formed from the molten state and consisting entirely of one mineral, we should not feel compelled to conclude that it was formed from a liquid which had a temperature higher than the melting-point of the mineral. In the case of rocks consisting entirely of olivine, a temperature approaching 1,890° for the liquid would be indicated by such reasoning, but when we examine inclusions with known thermal properties in such olivine rocks no evidence is found that they have been subjected to such high temperatures. We are forced to seek an origin for such rocks other than their formation from a liquid consisting entirely of olivine substance. Either the olivine crystals accumulated from a complex melt rich in other silicates which gave it a relatively low melting range, or the liquid, with respect to its silicate content, was substantially of olivine composition but contained considerable quantities of volatile substances now lost. Upon the relative merit of these two possibilities no general agreement has been reached. It

would carry us too far into geologic minutiae to discuss the pros and cons; indeed, we have perhaps already strayed too far in that direction for present purposes, but it has been deemed advisable to discuss rather fully the geological significance of some of these melting-points before pasing on to a consideration of other types of "fixed" points.

Inversion Points

A great many mineral compounds can appear in more than one crystalline form, and the temperature at which two crystalline forms (phases) are in equilibrium is called an *inversion* point. The most useful "fixed" points in geologic thermometry are inversion temperatures and their use depends upon the observer's ability to decide (a) which crystalline form of a substance is present in the rock and (b) whether that form was originally present or whether it has developed by inversion from another form. Decision upon the first question (a) is nearly always readily made; the second question (b) must at times be left open, but can be answered frequently enough to enable the establishment of definite conclusions. And here it is important to note that inversions may be broadly classified for present purposes into two classes, the prompt and the sluggish. In the former the substance changes promptly from the high-temperature form to the low-temperature form when the temperature passes downward through the inversion point, and the reverse change takes place as readily when the temperature change is in the opposite direction. Obviously, with such a substance, if crystallization takes place above the inversion point it will invariably give the high-temperature form, and if below the inversion it will give the low-temperature form. Obviously, too, the form observed upon examination of the rock at room temperature will always be the low-temperature form; therefore, we can use the inversion point as a recorder of temperature, if we can decide by study of this low-temperature form whether it is original or whether it was formed by inversion from the high-temperature form.

The sluggish inversions present a different picture. The high-temperature form of a substance having sluggish inversion may be cooled through the inversion point without the appearance of the low-temperature form, and it may be necessary to hold the temperature a little below the inversion point for a considerable period before inversion occurs. If, instead, the temperature is permitted to fall rapidly to room temperature, the high-temperature form will persist indefinitely. If the low-temperature form is heated, its temperature may rise above the inversion point without appearance of the new form, but it is the universal experience that there is much less lag in the rising-temperature direction. From these observations, which are of course made in the laboratory under controlled conditions, it might be supposed that the sluggish inversion would be more serviceable than the prompt as a temperature recorder. The finding of the high-temperature form of a mineral substance in a rock might be regarded as indicating that the rock formed above the inversion temperature, and the presence of the low-temperature form as indicating formation below the inversion temperature. Unfortunately, the situation is not so simple for it has been observed in many substances with a sluggish inversion—and it is probably true of all such cases—that the high-temperature modification can not only persist at low temperatures but can actually form at these temperatures. The high-temperature phase thus furnishes no indications as to temperature unless there is clear evidence that the substance was originally in the low-temperature modification and was transformed into the high-temperature modification. Then there is of course, undoubted evidence

that the temperature of the material had been raised to a point above that of the inversion. The low-temperature phase has not been observed to form above the inversion and probably can not. The presence of that form is, therefore, a definite indication of crystallization below the inversion temperature, provided the evidence is clear that the low-temperature modification was not formed secondarily by inversion of the high-temperature modification, and decisive evidence on that question is usually forthcoming.

With this amount of general discussion of the character of inversion points and their utility as fixed points in geologic thermometry, we may pass to consideration of a few examples. The substance silica, SiO_2, by reason of its widespread occurrence and its crystallization in a number of different modifications, is especially useful. There are four stable forms and therefore three inversions, which are as follows at the ordinary pressure:[2]

low quartz ⇌ high quartz		573° C.
high quartz ⇌ tridymite		870° C.
tridymite ⇌ cristobalite		1470° C.

The effect of pressure on the first inversion has been measured.[3] It is raised 21.5° by a pressure of 1,000° atmospheres which corresponds with a depth of some 2.5 miles in the earth. The effect of pressure on the second inversion can only be calculated from approximate values of the heat effect and volume change and appears to be significantly greater than the above and in the same direction. The third inversion lies at too high a temperature to be of any significance as a fixed point, but since cristobalite is a well-known natural mineral the conditions of its formation must be considered. The first inversion is of the prompt variety, the other two are sluggish. They are therefore to be used somewhat differently, and it may be added here that inversions, like melting-points, are used for two purposes: to indicate temperatures of initial formation, and to indicate temperatures to which immersed inclusions were heated.

In virtue of what has been said of sluggish inversions, it is plain that cristobalite and tridymite should be able to form at low temperatures; indeed, they do form at low temperatures in the laboratory, and they can not ordinarily be taken as indicators of high temperature. In many occurrences there is clear evidence from other sources that they were formed at moderate temperatures far below their stable ranges. Occasionally the one or the other is found as one of the minerals of a foreign inclusion in a magma and has characters indicating its formation by inversion from quartz. In such cases the definite conclusion can be drawn that heating above at least the 870° inversion has occurred, but the formation of cristobalite can not be taken to indicate heating above 1,470° because quartz has been observed in the laboratory to change directly to cristobalite below 1,470° and without passing through the intermediate stable form, tridymite. On the other hand, an inclusion which furnished evidence that tridymite was transformed to cristobalite would necessarily have been heated above 1,470°, but such temperatures are unknown in geology except perhaps in connection with two phenomena, the formation of fulgurites by lightning and the formation of impact craters by meteorites, phenomena which are, presumably, as much geologic as meteorologic or cosmic. In some of these instances silica has thus been heated not merely above its 1,470° inversion but above its melting-point at 1,713°, possibly above its boiling-point.

In geology proper, it is the lowest stable inversion of silica that is the most

[2] C. N. Fenner, *Am. Jour. Sci.*, 36: 331–384, 1913.

[3] R. E. Gibson, *Jour. Phys. Chem.*, 32: 1197, 1928.

serviceable. This change, involving high and low quartz, takes place at 573° and is of the prompt variety. All quartz as viewed at low temperature is therefore low quartz. The problem is to determine whether it was ever high quartz, in other words, whether it gives evidence of having passed through the 573° inversion and therefore of having been formed above 573°. A number of criteria are available, based on the change of crystal form and of volume which are known to occur at the inversion. They will not be enumerated here, but by their aid it can sometimes be decided whether or not the quartz was formed above 573°. It is a very useful reference point for the crystallization of many rocks and mineral deposits.

We thus see that, although persisting metastably and at times even formed metastably, nevertheless all the principal forms of SiO_2 are found in nature, even those which are stable only at quite high temperatures. Not all substances show like relations. There are a number of substances with known high-temperature forms which have never been observed in these forms in nature. Among these is the mineral wollastonite,[4] $CaSiO_3$. At approximately 1,140° it inverts to a different form, pseudo-wollastonite, which is known only in laboratory or technologic products. The inversion is rather sluggish, too, and it seems inevitable that pseudo-wollastonite would have survived in some rocks if it had ever formed. Or again, if some wollastonite is formed secondarily by inversion from pseudo-wollastonite, it should in at least some instances give evidence of that fact. No such evidence has been found. It is difficult to avoid the conclusion that in no rocks has the crystallization of $CaSiO_3$ taken place above 1,140°, nor yet has any rock, occurring as inclusions in a melt and containing wollastonite, been heated to a temperature as high as 1,140°. The substance $NaAlSiO_4$ furnishes another example of the same general relations. In the laboratory it is transformed at 1,248° to a modification which is quite unknown in nature.[5] The same reasoning applies to it as to the substance $CaSiO_3$. We are here concerned with a somewhat higher temperature, but there is confirmation of the conclusions reached on the basis of $CaSiO_3$. These and other substances with similar relations furnish indisputable evidence that the temperatures attained in geologic processes in the accessible part of the earth, were comparatively moderate, even in the highest-temperature stages of these processes.

On the other side of the picture, we have a number of substances which invariably give evidence of having cooled through an inversion point and therefore of having been formed above that inversion temperature. The evidence is ordinarily the presence of a complex twinning which is known to develop at certain inversion points. The majority of these inversions lie at comparatively low temperatures, and therefore, although the minerals concerned always form above the inversions, in no particular do they furnish evidence contradictory to the evidence cited above of the moderate temperatures of geologic processes. Among the substances in this class may be mentioned argentite (Ag_2S) with an inversion at 189°, boracite ($Mg_6B_{16}O_{30} . MgCl_2$) at 265°, cryolite ($Na_3AlF_6$) at 570°, leucite ($KAlSi_2O_6$) at 603°. The last of these is a rather high temperature, yet it appears that natural leucite has nearly always, if not always, formed above this temperature.[6]

[4] N. L. Bowen, J. F. Schairer and E. Posnjak, *Am. Jour. Sci.*, 26: 207, 1933.

[5] N. L. Bowen, *Am. Jour. Sci.*, 33: 560, 1912.

[6] Leucite, and indeed some of the other substances above listed as being in this class, may sometimes show twinning even when formed in the laboratory below the inversion temperature, but such twinning can usually be distinguished from that originating during inversion and has not been definitely recognized in the natural mineral.

Phase Equilibria in Polycomponent Systems

For the most part, only phase equilibria in systems of a single component have been discussed as "fixed" points. In each case they represent univariant equilibrium and, as already pointed out, are fixed only when the pressure is fixed or known. Any equilibrium may, theoretically at least, be equally useful, however great the number of phases involved, provided that the reaction is univariant, that is, that the number of phases exceeds the number of components by one. Some hint of the use of such equilibria has been given in the mention of melting temperatures of mineral assemblages. There are other kinds of equilibria among a number of phases that may be of service especially for the establishment of temperatures of mineral development in metamorphic rocks. Some of the reactions involve a gas phase and here the effect of pressure on any univariant equilibrium is so great that, unless there is field evidence which determines the approximate value of the pressure, the temperature of the reaction may be set only within rather wide limits. Even when the actual magnitude of the pressure is quite unknown, reactions of this type may have some temperature orienting value, especially where different reactions have taken place in different parts of a rock mass so disposed that all parts of it must have existed under substantially the same pressure.

The dissociation of carbonates with evolution of CO_2 is a reaction of the type under consideration. The dissociation pressure of calcite ($CaCO_3$) has been measured at temperatures up to those of melting, and in the light of this knowledge it is not surprising that examples of this reaction are not found in nature. To be sure, $CaCO_3$ dissociates freely with formation of CaO and CO_2 at a temperature of 900° when the pressure is only 1 atmosphere, but the weight of only forty meters of rock is sufficient to prevent dissociation at 1,100°. To such a temperature limestones have probably seldom been heated even at much greater depths.

Other carbonates such as magnesite ($MgCO_3$) and dolomite ($CaMgC_2O_6$) have higher dissociation pressures at corresponding temperatures, and their dissociation has occurred in nature. Magnesite is not a common mineral, but dolomite is common and geological evidence points to its dissociation when heated, with formation of periclase (MgO), calcite and CO_2 according to the equation

$$CaMgC_2O_6 \rightleftarrows MgO + CaCO_3 + CO_2.$$

From laboratory experiments something is known of the CO_2 pressures of this univariant reaction at various temperatures.[7] If there is field evidence revealing the depth of burial of a dolomite at a time when it was heated, say by contact with an igneous intrusive, it may be possible to reach some conclusion as to temperature, usually the fixing of a temperature above which it could not have been heated.[8]

Calcite itself reacts with certain other minerals, with evolution of CO_2, at temperatures far below those at which simple dissociation of calcite will occur. Thus calcite and quartz react according to the equation

$$CaCO_3 + SiO_2 \rightleftarrows CaSiO_3 + CO_2.$$

This is a univariant equilibrium and the pressure of CO_2 has thus a definite value for a given temperature. In some quartz-calcite rocks this reaction has failed to occur; in others it has occurred with formation of wollastonite ($CaSiO_3$). This difference of behavior is observed at times in adjacent parts of the same rock mass, from which facts it may be possible to reach conclusions as to the relative tem-

[7] W. Eitel, *N. Jahrb. f. Min., Beil. Bd.*, 51: 477, 1924.

[8] The experimental values indicate that even at a depth of 0.5 kilometer dolomite would be dissociated by heating to a temperature of about 600°.

peratures prevailing. The actual temperatures could be deduced only on the basis of experimental determination of the pressures of CO_2 for this reaction at various temperatures. No satisfactory results have been obtained. Calculations have been made of the values of the pressure at various temperatures, assuming the validity of the Nernst heat theorem.[9] These can give no more than a rough approximation of the truth, but until something better is available they are not without some value. The depth of burial being known, the failure of the attainment of a certain temperature is recorded in the rock by the failure of this reaction, that is, by the persistence, side by side, of calcite and quartz. The quartz-calcite association would be one of the more valuable temperature recorders if adequate knowledge were available of the *p, t* curve of this univariant reaction.

In addition to these reactions occurring in rock metamorphism and involving a gas phase, there are a great many reactions in which no gas phase is concerned. An example in which there are four reacting phases is furnished by the equilibrium between wollastonite and anorthite, on the one hand, and garnet and quartz, on the other, according to the equation

$$2CaSiO_3 + CaAl_2Si_2O_8 \rightleftarrows Ca_3Al_2Si_3O_{12} + SiO_2.$$

Since there are three components the reaction is univariant and has a definite *p, t* curve, but for it and most other reactions between a number of phases the information needed for the construction of such curves is lacking and knowledge regarding the temperature-pressure relations is available only in so far as field relations permit their placing relative to some of the reference points already discussed. Since many such reactions are, however, capable of furnishing independent fixed points, they no doubt will so function as experimental results are accumulated.

There is one unusual type of rock for which there is a great volume of experimental results applicable to the temperatures of formation of the constituents. This rock is that which occurs as beds of potassium salts, such as the Stassfurt salt deposits, the origin of which is still, in some of its details, an open question. Complex equilibria between a considerable number of phases are here concerned, and there are certain individual phases and again certain phase assemblages that have minimum temperatures of formation. These are useful temperature recorders. Among them we may mention only the individual phase vanthoffite, $MgNa_6\ (SO_4)_4$, with a minimum temperature of formation of 46° from the complex solutions, and the assemblage sylvite (KCl), kieserite ($MgSO_4 . H_2O$), halite (NaCl) with a minimum formation temperature of 72°. Since such temperatures can not be supposed to have existed during the evaporation of the natural brines, it must be concluded that the deposits have been subjected to these higher temperatures as a result of burial beneath a significant thickness of other strata, with consequent metamorphism (recrystallization) and formation of the higher temperature phases and phase assemblages.

The experimental investigation of the potash salt equilibria was carried out largely by Vant Hoff and his associates, and it is to him that we owe the expression "geologic thermometer."

Conclusions Regarding Temperatures of Geologic Processes

In their full details the conclusions reached as to temperatures of various geologic processes by the use of the various recorders are the concern of the geologist, but some general conclusions may be mentioned here.

[9] V. M. Goldschmidt, *Vidensk. Skr.* 1: (22), 1912.

The temperatures of magmas (molten rock) have seldom if ever exceeded 1,200° when they have arrived in that part of the crust of the earth which becomes accessible to observation as a result of erosion. Most magmas have probably not exceeded 900°, and some, especially those rich in alkali-aluminous silicates, have had temperatures little in excess of 600°. The temperatures of consolidation (crystallization) of the igneous rocks formed from these magmas are but little lower than the temperatures of the magmas themselves; in short, the magmas carry little super-heat. The temperatures of crystallization are highest for the rocks rich in lime-magnesian constituents and lowest for those rich in alkali-aluminous silicates and free silica. The temperatures of crystallization of pegmatites, which are formed from residual magmas especially rich in water and other volatile substances and are one of the storehouses of the radioactive elements, lie in the neighborhood of 573°. Mineral veins formed from the residual aqueous solutions after crystallization of the main rock constituents were deposited at temperatures, in part, approaching those of pegmatites and extending from this range down to the temperature of boiling water and even lower, with characteristic minerals at each stage.

So much for the rocks and mineral deposits formed in descending temperature stages of the geologic cycle. There are, in addition, rocks and mineral deposits formed under conditions attended by rising temperatures. Sediments and other materials formed at the surface of the earth and at the temperatures there prevalent may be buried under later accumulations and as a result of such burial they experience a rise of temperature. New minerals sometimes form, the original minerals invert to high-temperature forms and some assemblages probably suffer a certain amount of selective fusion. The extreme of reheating is experienced when such materials are immersed in molten magmas, in which case the more susceptible are themselves melted, but the indications are that even under these most extreme conditions rock materials have probably never been heated above 1,150°.

THE DETACHMENT OF SCIENTISTS?

The photochemical mechanism which produces plant life is one of the most basic of the processes that have made possible the complex evolution of life on this planet. We are a product of that evolution, and we have an underlying curiosity. It is not an idle curiosity, unless indeed the most stirring philosophies that have moved the mind of man are all idle. Far from being futile, it is the attribute which gives man such true dignity as he succeeds in preserving in the midst of the buffeting of his hazardous existence. To unravel one of the great mysteries of life is an ambition which needs no apologies, and it is this ambition which spurs us on to try to understand the primary plant process. We need no stronger justification for our conviction of the enduring value of what we do.

Our detachment makes it possible for us to keep the even tenor of our way and largely to devote our efforts to inquiries which are the most fascinating that engage the scientific mind, and which will require long and continuous effort by many men for their solution. Some of us certainly should depart at least temporarily from this sustained effort if we see a way in which our science may definitely aid in mitigating some great immediate ill that threatens humanity. Most of us can continue along the familiar path, with clear consciences, toward a distant goal. We should be humbly grateful for the opportunity that is ours, we should be full of sympathy with those who do not share our blessings, and we should be assiduous in the preservation of the spirit of true science in a time of exceeding stress.—*Report of the President of the Carnegie Institution of Washington, 1939.*

SOLUTION GARDENING

A NEW APPLICATION OF SCIENCE TO AN ANCIENT ART[1]

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THE scientific study of the mineral nutrition of plants has engaged students of plant physiology for about eighty years. Carried forward rapidly by means of refined laboratory experimentation, that study has resulted in an ever increasing fund of knowledge, much of which has become practically applied. That the nutritionally essential part of the soil is just its liquid phase—which is the soil solution—was soon established, and many kinds of plants were satisfactorily grown in experimental cultures without soil, with their roots in small jars of artificially prepared nutrient solutions. In some cases these solutions, made up from distilled water and highly purified mineral salts, were found to support as good growth as was had when highly productive soils were used, but that observation was beside the main point and it failed to attract the attention of gardeners or farmers. Nitrates, phosphates and sulphates of potassium, calcium, magnesium, ammonium and iron were employed in various proportions and partial concentrations, and a large number of excellent nutrient solutions was developed by numerous experimenters, for their laboratory studies. In the latter part of the eighty-year period boron, manganese, copper and zinc have been found to be generally essential for plant health, but they are required in exceedingly low concentrations. Some free oxygen is generally needed in the root environment and much attention has been devoted to soil aeration and to the aeration of experimental nutrient solutions. When acidity of solutions came to be seriously studied, it promptly emerged that this solution characteristic was markedly influential on plant health; it is generally necessary that a good nutrient solution be somewhat on the acid side of neutrality and plants frequently lower the acidity of the solution around their roots as they grow. To avoid uncertainties contingent upon alteration of the solution in the intervals between renewals, the special and very satisfactory technique of continuous flow was developed, whereby fresh solution enters the culture jar continuously, an overflow being arranged to care for the waste. Altogether, the experimental technique of controlled solution culture for the scientific study of nutrition is one of the most nearly perfect of all scientific procedures thus far developed; with suitable modifications it is now employed in many fields of research besides plant physiology.

With increase in knowledge about the mineral nutrition of plants the new findings and generalizations were promptly applied practically in agriculture and horticulture, and some of the most important advances in physiology were made by laboratory experimenters whose main interests were practical. Modern fertilizer practice was rapidly developed. Such salts as had been used in the laboratory were applied to the soil of garden and field with excellent results. Practically minded students developed their own experimental procedures for testing and improving the productivity of soils through experimentation with special

[1] An excellent account of the history of solution culture will be given by Dr. John W. Shive in an early number of THE SCIENTIFIC MONTHLY.

soil cultures, sometimes in pots but often by means of fertilizer-treated plats in garden or field. Analytical chemical techniques were developed for comparing the soil solutions of different soils, and a new science of soil chemistry came into being. Its numerous devotees were naturally not greatly interested in the theories of plant nutrition excepting as they might furnish guides to the large-scale growing of crop plants in soil. Experimentation with solution cultures was consequently left largely to those whose interests were mainly theoretical.

It was not very difficult to find out, by plat and pot experiments, what fertilizer applications had been beneficial on specific kinds or areas of agricultural soils—for the proof of a pudding lies in the eating—but to understand just why one fertilizer treatment proved to be more advantageous than another or why any specified treatment gave different results with different soils and crops, constituted a very difficult problem. Since most soils are very complex and variable and because they fluctuate so widely and rapidly in water content and in other respects, they do not lend themselves readily to artificial control and scientific study. Despite great advances made in the art of plant growing by means of soils, the relations between plants and the soils in which they are rooted still constitute a topic whose serious consideration involves numerous uncertainties and conflicting opinions, many blunted conclusions and vague hypotheses. On the other hand, although the laboratory practice of solution culture, highly developed as a subsidiary art for physiological study, still presents many uncertainties of its own, the relations between the plants of such cultures and their root environments are already relatively well understood.

An interesting modification of solution culture was introduced early in laboratory experimentation, a modification by which some of the less troublesome features of ordinary soil culture might be brought under surveillance without introducing many of the more troublesome features. Sand culture was thus brought forward, and it has been highly developed in the laboratory, along with true solution culture. Purified sand, or fine gravel, impregnated (but usually not saturated) with artificially prepared nutrient solutions and held in suitable containers, is employed as culture medium. Excellent mechanical support for the plants is thus provided. The roots ramify throughout the container and, since the solution is distributed in the sand or gravel without completely filling the interstices, this method facilitates root aeration through gas exchange with the air above. Used solution may be washed out and replaced at intervals or fresh solution may be added, either continuously or intermittently, with or without occasional temporary flooding; free bottom drainage is of course provided.

Although the techniques of solution culture and sand culture were devised and developed to a high degree of perfection, for the scientific study of plant nutrition rather than for the practical growing of plants, and although the increasing knowledge secured through their use in fundamental experimentation was promptly applied to practical soil culture in many ways, it is only in the last decade that these special procedures themselves have begun to be applied in gardening. Their introduction in that field is now well advanced. It constitutes the most fundamental improvement in garden practice to be proposed since specific chemical fertilizers began to be used on soils.

The refined laboratory methods have been so simplified and otherwise modified that their use constitutes two really new types of gardening, which are superficially different but essentially alike in

principle. Soils, and the complexity of uncertainties that arise from their use, are dispensed with altogether. Rectangular basins of concrete, sheet iron or wood, eight or ten inches deep and suitably coated with asphalt or asphalt emulsion, are employed instead of garden beds. For applied sand-culture technique the basins are nearly filled with clean sand, cinders or gravel, to which suitable artificial nutrient solutions are added, to be renewed at intervals or continuously. For applied solution-culture technique artificial nutrient solutions are used alone in the basins, without sand or other soil-like material. The plants are rooted in the wet sand or cinders, by which they are supported as though in soil, or else they are held at crown or stem base in a mat of excelsior, straw or the like, the mat being in turn supported by a simple asphalt-coated frame of wood and wire that rests on the basin rim while the roots extend downward into the solution below. The supply of both water and mineral nutrients is readily maintained by either method, according to any suitable solution formula and renewal plan, and the acidity of the solution is easily corrected from time to time as it becomes altered. Arrangements for adequate oxygen supply to the plant roots are easily provided. Since no soil is used, there is no spading or cultivation, nor is any weeding necessary, excepting perhaps in rare instances. Water and the fertilizer salts used are not lost through downward movement and leaching, which are of common occurrence when soil is used. Tap water—or sometimes rain water—and inexpensive commercial salts are used in preparing the solutions. Artificial temperature control may be applied to the basins when desirable, by means of simple arrangements. Finally, those insects, other animal pests, bacteria and fungi that attack cultivated plants from the soil are practically excluded. It is clear that these new techniques allow the gardener to control root environments with a much closer approach toward precision than can ever be possible in classic gardening.

For example, one of the many nutrient solutions that have proved satisfactory in solution gardening may be prepared as follows. Mix very thoroughly in a glazed crock or wooden box: potassium nitrate (KNO_3, saltpeter), 2,000 grams (70.5 oz.); calcium nitrate ($Ca(NO_3)_2 \cdot 4H_2O$), 300 grams (10.5 oz.); mono-calcium phosphate ($Ca(H_2PO_4)_2 \cdot H_2O$, or the fertilizer called treble superphosphate), 500 grams (17.5 oz.); magnesium sulphate ($MgSO_4 \cdot 7H_2O$), 500 grams; ferrous sulphate ($FeSO_4 \cdot 7H_2O$), 50 grams (1.8 oz.); cupric sulphate ($CuSO_4 \cdot 5H_2O$) and zinc sulphate ($ZnSO_4 \cdot 7H_2O$), each 2 grams (0.07 oz.); borax, $Na_2B_4O_7 \cdot 10H_2O$) and manganous sulphate ($MnSO_4$), each 4 grams (0.15 oz.). Use this mixture at the rate of about 4 grams (15 oz.) per quart of ordinary water and add dilute solution of sulphuric acid (H_2SO_4, 1 volume to 9 volumes of water) by small increments and with thorough mixing, until the acidity of the resulting nutrient solution gives an *orange* color with the dye chlorphenol red, or a *greenish-blue* color with the dye bromcresol green; strips of dyed paper may be used for such acidity tests. Acidity should be tested, and corrected, at short intervals throughout the growth period and the whole solution should be renewed at intervals of a month or less. Very many different prescriptions for nutrient solutions have been recommended on the basis of results secured in practical tests and many ways by which the plants may be mechanically supported and supplied with solution have been described.

The methods of soilless gardening are specially suitable for the culture of small plants of rapid growth, either in the open or in greenhouses, and for relatively small gardens rather than broad fields. They have already been successfully ap-

plied commercially in vegetable gardening and floriculture. Perhaps their greatest promise lies in their applicability to greenhouse culture and to small home gardens. The familiar and classic labor of preparing garden beds with spade and rake, of weeding, hoeing and all soil cultivation, are to be replaced by less laborious, more effective and much more interesting procedures, and the familiar uncertainties of watering as well as of fertilizing are readily avoided. Suitable basins may be used indefinitely and their relatively small cost may be distributed throughout many years. The seasonal cost of the fertilizer salts used is remarkably small. The operations of preparing and renewing solutions and those of testing and correcting solution acidity when necessary are relatively easy and intrinsically interesting. In many instances, the crops produced have been judged to be of better quality than are commonly secured in more or less comparable cases of classic gardening, and many crops are also much superior in quantity per areal unit of garden space. The upper limit of productivity for these new-type gardens seems to be set, for any kind of plant, by temperature and sunlight, by the occurrence of destructive storms and, as in soil culture, by the gardener's ability to combat the inroads of insects and other animals, fungi and bacteria, which may attack the aerial portions of the plants.

To guard against excessive optimism, it should be emphasized that soilless gardening is still in a very early experimental stage; consequently occasional failures or partial failures are naturally to be expected. Advance in the new field of application must still depend on practical gardening experience rather than on thorough knowledge of the esoteric and intricate details of plant nutrition. For small home gardens, whose owners like to experiment with different kinds of plants and different treatments or who like to lead in new interests, these methods are specially attractive.

When the use of artificial nutrient solutions instead of soils for practical plant culture was first proposed it received but little favorable comment either from plant physiologists or from scientific horticulturists, although those people may be supposed to have been well informed about the use of solution culture in scientific experimentation. But the novelty of the new gardening methods and the remarkably excellent results secured by their means quickly aroused great popular interest throughout this country and abroad, for many people are interested in gardens and in new ways of doing things. Popular articles promptly appeared in American newspapers and magazines, many of which were so highly imaginative and contained so many greatly exaggerated or untrue statements that the new gardening appeared miraculous to many who were unfamiliar with what had been going on in scientific laboratories for six decades. Although they certainly represent nothing new in the field of science, these methods are really new in the applied field of plant growing.

The practical use of artificial solutions without sand or other soil substitute, for vegetables, crop plants and ornamentals, was begun little more than ten years ago by Dr. William F. Gericke, of the University of California. It was he who introduced the newly-coined word *hydroponics* (water culture), to distinguish what may now be called "Gericke gardening" from classic soil gardening on the one hand and from applied sand culture on the other. The term aquaculture had been applied to the growing of animals and plants in natural waters with soil bottoms, such as ponds and streams. Others have employed the expressions *chemiculture* and *soilless* gardening to mean simply gardening by means of artificially prepared nutrient solutions.

either with or without sand or similar solid material.

The commercial use of artificial solutions with sand, gravel or cinders in greenhouses has been developed parallel with Gericke gardening. That development began with sand-culture tests by Dr. John W. Shive and his associates at the New Jersey Agricultural Experiment Station.

Whatever terminology may eventually come into general use for these new types of gardening and whatever practical results may be achieved through the new methods, the theory and technique of growing plants with an artificially controlled and fairly well understood supply of mineral nutrients has now begun to spread outward from scientific laboratory to ordinary garden, window garden and greenhouse. Thus an additional chapter of scientific knowledge and of the application of the scientific method of thought is attracting many thousands of intelligent people who might otherwise hardly be aware of the existence of the science of plant physiology. This popular movement is perhaps socially just as important in that less tangible way as it is from the more obvious and prosaic standpoint of vegetable and flower production. Some knowledge about the mineral nutrition of garden plants and their relations to their surroundings, together with homely familiarity with some of the methods of experiment and thought by which such knowledge has been and is being built up, should lead toward broader and better appreciation of the nature of plant life among people whose main interests lie elsewhere.

At least eight recent popular books on the new gardening present the subject in many different ways. All are good. These books are briefly characterized in the following paragraphs.

(1) One of the earliest, if not the very earliest, of the books devoted to practical soilless gardening was the first edition of Dawson and Dorn's little volume,[2] which is now in its third edition, to which reference is here made. The story is told clearly and interestingly, for readers who are largely unfamiliar with biological and chemical knowledge, and it is exceptionally reliable and complete for such readers; it is also brief, but it is accompanied by many helpful references of various kinds. It gives answers to most of the simple questions that might be asked by a naive beginner and it contains also many original observations based on experience. Familiar, as they say, with the common man's "hunger for information on wholesome subjects," the authors express the hope that "the process of certain chemicalization of [human] food values by means of deliberate fertilization" (artificial control of plant nutrition) will aid toward "mankind's well-being without the heavy toil of cultivating the earth."

(2) Ellis and Swaney[3] are also pioneers in this field of popular writing. Their book is now in its third printing. An elementary account of some features of plant physiology constitutes the first chapter and a subsequent chapter presents some information about organic growth-promoting substances. Solution, sand and cinder culture are clearly described, with many illustrations, some of them colored. Special attention is devoted to window gardening and the culture of plants in the home. A number of formulas for nutrient solutions are

[2] C. D. Dawson and M. V. Dorn. "Plant Chemiculture, a Guide to Experiments in Growing Plants without Soil." 3rd revised ed., illustrated, about 130 pages. Publ. by the authors, Los Angeles, 1939.

[3] Ellis, Carlton and Miller W. Swaney. "Soilless Growth of Plants: Use of Nutrient Solutions, Water, Sand, Cinder, etc." Illustrated, about 150 pages. Reinhold Publishing Corporation, New York, 1938.

given. The authors offer to supply a trade-named mixture of salts ready for use by amateurs; indeed the book bears a coupon entitling the purchaser to a free sample of the mixture.

(3) A volume by Connors and Tiedjens,[4] which comes from Rutgers University and the New Jersey Agricultural Experiment Station, is at once readable, practical, scientific and reliable. It presents not only many of the main elementary considerations concerning plant nutrition and plant culture with and without soil, but also much information and discussion such as are generally found only in technical publications. The book is well illustrated with drawings and photographs, some of the latter colored.

(4) Commercial growers as well as amateurs should gain much from Turner and Henry's book,[5] which is generally both scientific and practical as well as scholarly. Main attention is given to greenhouse culture by means of gravel or cinders. Many solution formulas and extensive instructions are given, with useful illustrations showing methods and results. Several colored plates add to the general attractiveness of the volume. The authors' observations on the suiting of solution composition to light conditions and to seasons of the year are of special interest; for example, a good solution for rose culture in December at Urbana was found to be unsatisfactory in June. These authors offer to supply reagents used in testing solutions for the main nutritive elements.

[4] Connors, Charles H. and Victor A. Tiedjens. "Chemical Gardening for the Amateur: Gardening without Soil Made Easy." Illustrated, about 250 pages. Wm. H. Wise and Company, New York, 1939.

[5] Turner, Wayne I. and Victor M. Henry. "Growing Plants in Nutrient Solutions, or Scientifically Controlled Growth." Illustrated, about 150 pages. John Wiley and Sons, New York, 1939.

(5) A book by D. R. Matlin,[6] constitutes an elementary primer, introducing artificial solution culture at the high-school level. It gives simple accounts of elementary chemistry and plant physiology, includes a number of attractive illustrations and brief but clear directions for installation and care of cultures. A number of solution formulas are presented, with adequate detail. The account is largely a report on the author's own experience or on that of his young students at a Los Angeles high school. This is a handy and interesting little book for beginners; it should arouse interest and encourage experimentation and thought.

(6) An excellent book on the new gardening is by Dr. William F. Gericke,[7] whose pioneer experiments on the practical application of solution culture aroused the present wide-spread interest in these new gardening methods. Before turning to this application, its author had been engaged for many years in physiological studies on the mineral nutrition of plants, and this account—which is his first comprehensive publication on solution gardening—is replete with both practical and scientific observations of many kinds. Directions are given for the preparation of basins, supporting mats and nutrient solutions, for solution testing and renewal, and for the general care of cultures. The story of the author's early trials and of the subsequent development of his improved techniques is of special interest. Tests

[6] Matlin, D. R. "Growing Plants without Soil: The A–B–C of Plant Chemiculture (Soilless Agriculture, Chemiculture, Water Culture, Hydroponics, Tank Farming, Sand Culture), Including Plant Growth Hormones and Their Use." 2nd revised ed., illustrated, about 50 pages. Chemical Publishing Company, Inc., New York, 1940.

[7] Gericke, William F. "The Complete Guide to Soilless Gardening." Illustrated, about 280 pages. Prentice Hall, Inc., New York, 1940.

with a very large number of plant forms are reported, mostly in outdoor culture at Berkeley, California; a partial list of the forms tested includes: tomato, cucumber, watermelon, squash, potato, sweet potato, maize, parsnip, carrot, beet, turnip, radish, onion, lettuce, cabbage, parsley, celery, strawberry, marigold, narcissus, tulip, gladiolus, dahlia, fuchsia, gardenia, rose. Several forms were sometimes grown one after the other in the same basin, to produce a succession of crops in a single season. The book is written in attractive, readable style, sufficiently simple for intelligent beginners but generally precise enough for those who already know their plants.

(7) Somewhat more than half of Alex Laurie's excellent book[8] is devoted to the elementary principles of soil culture and it should be very valuable to any gardener. Sand culture, gravel culture and hydroponics are clearly described, mainly for greenhouse production, and a final chapter is devoted to some special culture methods for amateurs. This is a readable and reliable presentation. The author, who is professor of floriculture in Ohio State University, is a scientific horticulturist, interested in aiding commercial growers as well as amateurs. The book is well illustrated.

(8) "Gardening without Soil," by A. H. Phillips,[9] is a delightful presentation of this subject from a British view-point. Exceptionally well written and satisfactory, it seems to be sufficiently complete, although it may hardly be taken to "offer all the information at present obtainable on the subject" or to be "as practical a guide to this new science as it is possible to collate," as the introduction not too modestly says. A detailed account of some actual cultures carried out in England in 1938 is added as a short appendix. The usual brief account of the main elementary principles of plant nutrition is followed by clear and concise directions for installing basins and plants and for their care. The techniques described are based on those of Gericke, with some modifications. Correct emphasis is placed on the importance of root temperature; for many plants, best results are to be expected when the solution temperature is kept between 70° and 75° Fahrenheit. A number of diagrams and photographs are included, which illustrate and add to the general attractiveness of the volume.

[8] Laurie, Alex. "Soil Culture Simplified." Illustrated, about 200 pages. McGraw-Hill Book Company, New York, 1940.

[9] Phillips, A. H. "Gardening without Soil." Illustrated, about 140 pages. Chemical Publishing Company, Inc., New York, 1940.

"THE TRUE MISSION OF THE RACE"

THERE is still a duty to keep the torch of pure science lit, and this duty is only the greater under stress. All the long struggle of a harsh evolution, the pitting of species against the environment, has produced a being whose primary distinction is conscious cerebration, and whose crowning attribute is his intellectual curiosity concerning his complex environment and a thirst for knowledge transcending the mere struggle for existence. If there is no abiding value in a Beethoven symphony, or a theory of the cosmos, or the tracing of an ancient culture, then the Carnegie Institution of Washington has scant reason for existence. If it is really good that man should look at the stars and should contemplate his great destiny, then it is imperative that in those regions which enjoy the blessings of peace the search for the eternal verities should continue.

The dual character of science influences much of our outlook. We look at the stars, and we build yet greater machines to aid our vision, for two reasons. The stars are a laboratory, wherein are pressures and temperatures far beyond those we can artificially produce; which we can merely observe and not manipulate. Nevertheless, through thus observing we have already learned many things which have advanced the science of physics and in turn its applications. All this is to be welcomed, yet it should not completely dominate our thought. We also look at the stars for the same reason that inspired the shepherd on the ancient hill, because we are bound to think of greater things than the comforts or dangers of the morrow, perhaps because thus to inquire and to speculate is the true mission of the race.—*Report of the President of the Carnegie Institution of Washington, 1939.*

A SERPENT-SEEKING SAFARI IN EQUATORIA

PART II
CONGO AND TANGANYIKA TERRITORY

By ARTHUR LOVERIDGE

MUSEUM OF COMPARATIVE ZOOLOGY, HARVARD COLLEGE

THE steamship *General Tombeur*, on which we sailed down the lake, was a comfortable little craft, and we greatly enjoyed the lovely scenery—rocky scarps and verdure-clothed islands set in a placid lake beneath an azure sky. Later in the day black clouds gathered and we were subjected to heavy rainstorms. It was after sunset before we reached Mamvu on Idjwi Island, and we should not have done so at all but for the exceeding kindness of Mons. v.d. Berck v. Heemstede, who came off in his launch and took us, together with our camping equipment, ashore in the beautiful bay in which he has made his home. Nor was this all, for the family placed the tennis lawn at our disposal for the pitching of tents and entertained us most hospitably. To sit in their comfortable lounge and listen to music from Brussels and Berlin or a B.B.C. broadcast was an unforgetable experience. The island in a Central Africa lake had seemed so remote and cut off from the world, yet here was the day's news brought to us from troubled Europe!

As soon as porters could be provided we set off for the mountain which dominates the island, and pitched our tents at Mulinga. From this altitude I made daily excursions into the forests that cap the surrounding heights. The race of blue monkeys peculiar to this island, named *schoutedeni* after the director of the Musée du Congo Belge, was becoming rare, and two were shot only with considerable difficulty, for the animals were much harassed and hunted by the Batwa pigmies, whose shouts and cries when in pursuit we heard on several occasions. I also came on the primitive shelters which these little people make in the bush, and once, when caught in a terrific thunderstorm far from camp, witnessed the celerity with which my pigmy guide could construct such a refuge. This man, son of a chief, though of very short stature scarcely seemed to me to be a full-blooded Batwa. He first came to my camp with a dwarf species of lemur and, appropriately enough, followed this up with a pigmy chameleon! After paying for them I made him a present of several razor blades. They proved irresistible, for he ruined his good looks by shaving his head bald, after which he looked ugly indeed.

Ujiji, famous as the meeting place of Livingstone and Stanley, is only five miles from Kigoma, and we drove out there to pitch our tents beneath the mighty mango trees under which I had camped in 1930. Then I was in search of a limbless lizard known only from two examples in the Berlin Museum. Once again I failed to find it, but fortunately the natives were more successful, bringing in five towards the end of our brief visit. Better still, while hunting for the elusive burrowing creature I discovered a new species of skink of which we got a good series. Another interesting find was the first Tanganyika record of a so-called "two-headed snake" (*Chilorhinophis*). The stumpy tail of this handsomely colored and exceedingly elongated serpent is marked precisely like the head, even to eye-spots. As the reptile wriggles along, its head is applied to the ground, but

the tail is upraised clear of the ground and poised as if about to strike. Thus one receives the impression that the snake is wriggling backwards, alert and ready to fight a rearguard action rather than suffer any interference!

Not content with having asked the District Officer at Kigoma to instruct the Liwale of Ujiji to announce to his people at a dance that I was anxious to buy limbless lizards and snakes, I lost no opportunity of drumming it in by stopping almost every native I met. For example, a lad with ragged shirt would be sitting idly outside his hut. Halting abruptly, I would ask if he wanted a new shirt and get an eager affirmative. "Then why sit idly there when you can get thirty cents (8c U. S.) for every limbless lizard or snake which you bring me. You've only to get fifteen and you'll be able to buy a new shirt yourself. Remember, it's only this week that I'll be here." A little later I was superintending the turning over of a likely mountain of rubbish surrounding a mango tree in a native plot: two natives from the adjacent *shamba* (garden) strolled over to watch and inquire what we were doing. "Looking for snakes with two mouths," I replied in the vernacular, following this up with the usual patter. Just at that moment my boys uncovered one (*Typhlops graueri*); I seized and transferred it to a lethal bottle. "That's thirty cents lost to you," I commented to the onlookers. A second followed the first. "You might have had sixty cents if you'd only had the energy to turn this over." Came a third, all within ten minutes. I did recall such good fortune before, but keeping a straight face I continued airily: "Ninety cents just thrown away." Their eyes were round with astonishment and they

HOME SWEET HOME IN THE HEART OF AFRICA

ONE OF THE HOMES PASSED BY THE EXPEDITION. CONTENTMENT ABIDES WITH FEW POSSESSIONS.

A SEMI-PIGMY OF THE BATWA TRIBE
THIS MAN, CLOTHED IN A CIVET SKIN, WAS ONE OF HUNDREDS WHO VISITED OUR CAMP AT BUNDIBUGYO IN WESTERN UGANDA.

conferred together rapidly. "We will hunt for them to-morrow," said one. "To-morrow, to-morrow," I gibed. "Always, to-morrow; and to-morrow the sun will be hot and you will say 'To-morrow.' And the day after the day after that I shall be gone, and then where will you find a European who is fool enough to pay 30¢ for a snake?" "We will go now," they chorused, and set off to find a hoe. We continued digging for an hour but failed to find another snake, neither did they!

For two of us the safari was drawing to a close. My wife was busy packing the last of nearly two thousand plants which she had collected for the Gray Herbarium; with Brian's departure I was to lose my photographer-in-chief, who had taken all the photographs which illustrate this account. Mournfully we entrained for the forty-six-hour journey to Dar es Salaam on the coast.

Our train was running late, so it was a tired trio that reached the New Africa Hotel at 8 P.M. on Saturday night. On arrival we learned for the first time that the little coastal steamer *Tayari* was scheduled to sail for Mikindani at 6 P.M. the following Monday. However, sailings for Mikindani were too few and infrequent to be passed over lightly, so I decided to catch the *Tayari*, leaving my wife and son to sail for Europe the following day.

It was at Mikindani that the Yao tribe revolted in 1888 and drove out the Germans. Twenty-two years earlier Livingstone had landed here and taken the old trail across the hills to the Ruvuma River on his way to Lake Nyasa. His companion, Kirk, later Sir John Kirk, Her Majesty's consul at Zanzibar, accompanying him at the outset, had collected three little sedge-frogs in Ruvuma Bay. These had subsequently been described as new

A BANYARUANDA RAINCOAT
IN THE MOUNTAINOUS, WIND-SWEPT COUNTRY OF SOUTHWESTERN UGANDA, PASTORAL PEOPLE HAVE DEVISED A LIGHT AND SERVICEABLE SHELTER OF BAMBOO AND BANANA LEAVES TO PROTECT THEM FROM WIND AND RAIN.

by Dr. Günther. The status of two of them was somewhat obscure but might be elucidated if fresh topotypic material were secured—hence my journey—over the hills I went—but by lorry.

Camp was made on the banks of the Ruvuma commanding a fine view of the spot where the German forces under von Lettow Vorbeck retreated into Mozambique on the night of November 25–26, 1917, leaving German East Africa in the hands of the British. A lion, we learned, had taken a man from his hut four days before our arrival, and within a couple of miles of our camp. As we drove along I had noted the stout stockaded chicken houses, mostly on stilts.

As sedge-frogs usually remain under water by day, only ascending the sedges at night, it was necessary to hunt them after dark by wading in the swamps with flashlights. While I was protected by hip-high wading boots the legs of my two native assistants were bare. The very first night we were successful in getting one of the species, which subsequently proved to be very common in the region. The third night we shifted to another extensive swamp separated from the crocodile-infested Ruvuma by a hundred feet or so of low bank. We had been hunting for half an hour when one of the boys cried "Quick, sir! A turtle!" I hastened as best I could to where he was, but by the time I got there the turtle had decamped. These turtles were "flapjacks" of considerable size; the largest of eight which we collected weighed twenty-five pounds. "Of course," added Kizamba, "this water is plenty deep enough for crocodiles too." The next night there was a yell from Ali, who got a horrid fright from treading on a turtle in deep water.

Previously no thought of crocodiles had crossed my mind. Now that Ki-

A MNYARUANDA DANDY AT NYAKABANDE

THIS YOUTH PROBABLY OF THE HORORO SECTION OF THE TRIBE, EXHIBITS ONE OF THE NUMEROUS TYPES OF COIFFURE FASHIONABLE AMONG THESE PEOPLE. A RAZOR BLADE WAS THE PRICE HE CHARGED FOR PERMITTING HIS PORTRAIT TO BE TAKEN.

A MNYARUANDA WITH CROWNED CRANE

THE BIRD DEPICTED IS ONLY A NESTLING, AND AS SUCH FALLS EASY PREY TO THE NATIVES, FOR THE NESTS OF THE CRANES ARE ONLY A MASS OF SEDGES IN SWAMPS OR ALONG EDGES OF LAKES.

BUYING ETHNOLOGICAL MATERIAL ON CHRISTMAS EVE
IN THE BWAMBA COUNTRY OVERLOOKING THE SEMLIKI VALLEY WE LEFT ZOOLOGICAL PURSUITS TO OBTAIN MATERIAL FOR HARVARD'S PEABODY MUSEUM.

zamba had mentioned it we all knew that in the middle, where the water was probably up to our necks, it *was* deep enough for the creatures. Next day as I was returning from an excursion with a local native acting as gunbearer, we had to skirt this swamp when the "boy" remarked quite casually: "I once saw three crocodiles basking together at this very spot." Asked when this was, he thought for some moments, then replied: "The day before your lorry arrived here. I remember because I was gathering firewood for an Indian at the time." "They were only four or five feet long," he added in response to a further question. Undeterred by this information, we returned again and got examples of the second species.

On the seventh day of our stay it poured the whole time and much of the night as well. Next morning we heard a noisy crowd of men and boys coming down the road. As they drew nearer it was seen they carried something on a stretcher. It turned out to be a stocky female crocodile measuring eight feet from snout to base of tail, but only three feet of truncated tail—the remaining five or so had been lost long since, for the stump was well-healed. It had wandered from river or swamp during the heavy downpour of the previous night and had been found resting in a field of maize.

Torrential rain fell during our stay, so that when the time came for us to move up the coast we had to proceed by native dhow from Mikindani, for no other craft would be available for several weeks. I arranged with a dhow master and confirmed the arrangement late on Saturday night that his dhow should be at the

wharf at 7 A.M. on the following Monday. We reached the wharf at 7 : 15, but alas, there was no dhow! The owner lived a mile round the bay; when he had been located he sent word that his craft was unseaworthy, so he could not take us! We could go by another dhow, which was leaving for Lindi at 11 A.M., he added. Instead of having the sole use of a dhow and getting away in the cool of the morning, we had to pile in on top of a lot of cargo, and it was near noon when we beat out of Mikindani Bay.

Midafternoon found us becalmed and for two hours we lay idly rolling in almost sweltering heat, despite black clouds over the land which from time to time deluged the coast with rain. It was shortly after sunset when we entered Lindi Bay, and then ensued three hours of almost fruitless tacking until the Arab captain, acting on my suggestion, cast anchor—a rock secured by rope—at 9 P.M. My camp bed was erected on the tiny afterdeck and I passed a refreshing night beneath the stars, sleeping without a mosquito net for the first time in six months, and waking at midnight to the luxury of a shiver! At 5 A.M. I was turned out, as the deck was required by the crew who had to haul on the sails. We reached land at 7 A.M., and ten minutes later I jumped ashore exactly opposite the Beach Hotel, where a bath and breakfast awaited me.

Our next destination was Mbanja, where Herr Ewerbeck, a former German administrative officer of Lindi, had collected yet another species of limbless lizard (*Chirindia*), examples of which we hoped to procure. Apart from other considerations it seemed advisable to secure a large series so as to be able to study the range of variation within a species of these degenerate, worm-like creatures, which are so rare in collections. When

A BIRD SKINNER AND HIS APPRECIATIVE AUDIENCE

WHEREVER WE WENT OUR SKINNERS WERE ASSURED OF AN AUDIENCE OF THE NEIGHBORHOOD'S SMALL BOYS. THE PROBLEM WAS TO SNAP THEM BEFORE THEY TURNED TO FACE THE CAMERA.

AN ARBOREAL FROG OF THE GENUS RANA

RELATIVE OF THE GREEN AND LEOPARD FROGS OF THE UNITED STATES, THIS SPECIES HAS DEVELOPED DISKS AND DWELLS IN THE TREES OR BANANA PLANTS.

SENEGAL FROG

THE RINGING NOTE OF THIS SPECIES SOUNDS LIKE A BURSTING BUBBLE OF WATER. WHEN MANY FROGS ARE ASSEMBLED, AS AT THE BREAKING OF THE RAINS, THEY CAN BE HEARD A MILE AWAY.

our lorry drew up at Mbanja village, however, I said "Drive on," for the village was situated on sunbaked clay and coral limestone among crocodile-infested lagoons and tidal estuaries. An amphisbaenid would, I knew, scorn such an environment, demanding a sandy or laterite soil for its habitat. When I explained this to my native driver, he nodded. "I know just the place," said he, and drove me up to the landing-field or aerodrome. Judge of my surprise on arriving there to find this magnificent stretch of flat country ditched or trenched in every direction. Later, I learned that at the time of Italy's seizure of Albania, there were good reasons for rendering the landing-field uncongenial to troop-carriers—hence the trenches. Now for the sequel—how Italy's annexation furthered my plans and benefited Harvard's Museum!

A gang of eight natives was about to fill in the trenches. I explained to them carefully just what I wanted, offering the usual 30 cents (8¢ U. S.) each for fifty undamaged examples of this creature. A look of chagrin flitted across the face of one of the men, and he made some comment in the vernacular to the foreman. "What was that he said?" I asked. "He says that he flicked one of them out of the way when he ran ahead of your lorry to show the way." This sounded promising; moreover, during the clearing of our camp site the men captured two little jet black worm-snakes—like the lead of a pencil come to life. This had given me the opportunity to demonstrate factually the offer of 30 cents. To make a long story short, my boys and I secured ten of the pink worm-like lizards, while sixty others were brought in by natives, chiefly the aerodrome gang engaged in filling in the trenches. They marveled at the ways of a white man wanting such worthless 'worms.' Just nine months before I had had to send to Hamburg to

borrow the damaged and only known example of the species!

As I was sitting down to tea in the entrance of my tent, an eagle settled in a tree a quarter of a mile away across the landing-field. Abandoning tea for the moment, I crossed to where it was and as I returned with the bird a number of local natives crowded round. "Good, good work," they chirped, "eater of chickens." "On the contrary," said I, "this big bird is a friend of yours, for it never eats chickens, and when Ali has skinned it you will probably find snakes in its stomach." As I drained my last cup of tea there were roars of laughter from the skinner's quarters. I walked over to see what was the cause. Ali, sitting in the shade of the mango trees, had just produced a three-foot stripe-bellied sand-snake from the eagle's crop. "Go ahead," said I, "open its stomach." When this was done two more snakes, of the same species but slightly smaller, were disclosed!

Though officially the rainy season, we had enjoyed *almost* a week of fine weather while at Mbanja, so it was just misfortune that during our last night a gale arose followed by torrential rain. I awoke at 1:45 A.M. as a tent pole snapped and got up to render first-aid. It was the end of sleep for me. Breakfast was over by 6 A.M., but the lorry which was coming for us got bogged and we did not get away until 8 A.M. It was what you might call "a day" in Africa or anywhere else, for my next meal, except for four pigmy bananas, was at 9:10 P.M. with clouds of mosquitoes from nearby Lake Rutamba humming and biting. To reach the lake we had had a march of three and a half hours, most of it in the dark, for the lorry had balked at a crazy bridge, honeycombed and undermined by termites.

While on this march we halted near a native hut whose owner hospitably

DWARF GALAGO FROM IDJWI ISLAND

APPROPRIATELY ENOUGH, THIS DWARF LEMUR WAS BROUGHT IN BY A HUMAN DWARF, REMNANT OF THE FOREST PIGMY RESIDENTS.

A PIGMY CHAMELEON

ONCE MORE, IT WAS A PIGMY TO WHOM WE WERE INDEBTED FOR THIS PRIZE. MEMBERS OF THIS GENUS LACK THE PREHENSILE TAIL OF THE LARGER SPECIES AND THEIR COLOR REPERTOIRE IS RESTRICTED TO THE TINTS OF DEAD LEAVES.

COMMON FROGS OF AFRICA
THE GREAT CREATURE ABOVE IS SO ADAPTED TO AQUATIC LIFE THAT IT RARELY VENTURES ON LAND. BELOW IS AN ENAMEL-GREEN FROG FROM A BANANA. TREE FROGS OF THIS GROUP WERE MOST ELUSIVE THOUGH THEIR RINGING CALLS WERE FREQUENTLY HEARD IN THE FOREST.

climbed a palm and gave us cocoanuts to assuage our thirst: Tabula, my Mganda servant, having drained a nut of its milk, turned to smash it against the stem of the palm. Immediately cries of protest arose from the group of local natives who had gathered round. "Why not?" queried Tabula, surprised, to which our host replied, "The palm tree says: 'You have drunk of my milk, now you beat me without cause, well, I'll show you,' and drops a cocoanut on your head." At Mbanja I had seen two corncobs, tied together by string, hanging on the bole of a cocoanut palm owned by an intelligent headman. "To insure fertility?" I queried. "Yes," he replied, "it is to make the tree bear better."

Monday found us all eager for the climb to Rondo Plateau. A casual remark, which some one had made to me in Lindi to the effect that a forest officer had recently spent several months surveying a reserve up there, decided me to include this patch of forest in my itinerary, for a lumber company was negotiating for a concession to remove the huge *mvuli* trees which were its greatest asset. Striding along the narrow path which traverses the length of the plateau, I encountered a limbless lizard and then a soft-shelled land tortoise lying dead. This was a good augury, for neither species had been met with during the course of this particular *safari;* the skink, a *Melanoseps,* was distinctly rare.

Our tents were pitched on a camp site cleared by the forestry officer the previous November. At that time three lions had been making themselves obnoxious to the Rondo Mission, which we had passed some hours before. The lay brother had trapped one and on going to shoot it had wounded another when it dashed up and clawed at the trap that held its companion. The survivor had gone on to the forestry camp and in snooping 'round, got under the tent-ropes, took fright and decamped.

Having reduced two loads by feeding my family of fifty porters, we turned in early, and were on our way shortly after dawn the next morning. On reaching

the forest, we found a spacious clearing and a well-built, but empty, hut. We soon had the latter open and a fire made, while tents were being pitched. Here, at nearly 3,000 feet, the climate was delightful, and my tent, set thirty feet back from a thousand-foot escarpment, commanded a magnificent view of the forested slopes opposite, for the plateau is shaped like a horseshoe at this point. Each morning the view was obscured by a solid wall of vapor that never blew away before 9 A.M.; every night this vapor was wafted up, condensed on the trees high above my tent, and, with each gust of wind, showered like pellets upon the awning. Water is something of a problem for none is to be found upon the plateau and it was necessary to send to the foot of the escarpment for it. The nearest natives were nearly three miles away.

The morning after our arrival a forest guard appeared. "Yes," this was his hut, he had abandoned it because he got tired of the lions. They *would* use the clearing for a playground and then come sniffing round the hut. "No," it wasn't just once or twice, but every night. It was only a matter of time, he thought, before they would be sufficiently hungry to break in. Hadn't we heard that a child had been taken on Friday, and a man within the month? Well, we hadn't, but neither had we been camped there a week before a boy of twelve, son of the *mwalimu* (local headman), was taken in broad daylight. The lion dashed into a hut, seized the lad and made off with him. Fortunately the boy's parents were also in the hut and raised a hue and cry; the boy, or his body, was recovered, but the lion escaped.

Rondo Plateau surpassed all previous camps in interest; this isolated remnant of forest contained forms which were closely related to the Usambara fauna, 250 miles to the north. It was with regret that I returned to Lindi, a township far too clean to be productive of much "vermin." While awaiting the arrival

AFRICAN RODENTS

ABOVE IS A DORMOUSE OF THE EASTERN CONGO, WHICH LIVES IN THE BANANA PLANTS AND MAKES A DELIGHTFUL PET. THE HARSH-FURRED, RUFOUS-COLORED COMMON RATS OF THE VARIETY SHOWN BELOW, ARE FOUND ON MOST OF THE MONTANE MASSES OF EAST AFRICA.

of the *S.S. Dumra*, our persistent efforts met with one success in the finding of

A SLENDER SKINK
THE SKINKS OF IDJWI ISLAND HAVE BEEN HONORED BY A SPECIAL NAME, BUT ONLY DIFFER IN THEIR RICH COLORING OF RED AND ORANGE, FROM THEIR ALLIES ON THE MAINLAND.

two little Oriental burrowing snakes (*Typhlops braminus*) under some rotting thatch. These constituted the fourth and fifth records respectively for its occurrence in East Africa.

On landing at Tanga, we made our first camp by the ragged remains of forest surrounding the Siga Caves on the Mkulumusi River. According to native reports, these caves extend for half a mile through the limestone, and a party of Germans went in and never came out—a story probably devoid of truth. At any rate, the eerie neighborhood furnished us with the noisiest nights of the whole trip: the sharp staccato "barks" of hyrax on the cliffs, the wild unearthly cries of the galagos, and the hooting of owls doubtless contributed to the sinister reputation and prestige of the spirits which are said to dwell in caves.

Three times during our brief stay medicine men passed through our camp to perform rites at the entrance of the largest cave. One *mganga* was a very modernly-attired gentleman in fez, khaki shirt and shorts, a waterbottle at his belt. One patient was a sick woman brought on a wheel-barrow, accompanied by a man, probably her husband, bearing a white cock. The latter was beheaded at the entrance and left there after rites which lasted more than an hour. Another patient brought twenty eggs, I was told. Had I known this earlier I should have appropriated them, for we had had considerable difficulty in getting eggs. This would have afforded satisfaction as evidence that the "spirit" had accepted the gift! On our first visit I salvaged for the Peabody Museum the single horn of Grant's gazelle which we had found stuck in the entrance. There were feathers of several luckless fowls and two cents, which I presented to my companions who accepted them with considerable hesitation. The spirit was supposed to accept these offerings, but it was army ants (*siafu*) which I found consuming the white cock, and I fancy that leopards accounted for most of the other fowls.

It was the bats, however, which interested me; thousands of them had their home in the lofty water-worn passages. We soon located them in a side passage where they were hanging at a height of about sixty feet above a stagnant, stinking pool. It was rather a problem to shoot them so that they would fall in the

shallow end from where it would be possible to recover them with the aid of a butterfly net. Outside the caves I netted four other species, and one evening in the gloaming I shot my first bat-hawk (*Machaerhamphus*) as it dashed hither and thither. In its stomach was a free-tailed bat of a species abundant in the caves. It had been swallowed whole, as is customary with these hawks whose wide gape makes them to bats what a nightjar is to moths.

While camped at Siga I received a visit from Mr. Hugo Tanner, of Amboni and other estates. He showed me the greatest kindness, as did all the members of his staff. Mr. Keller drove me about to inspect the principal patches of forest remaining on the Amboni Estate, which covers nearly eighty square miles. This enabled me to select a suitable site to which my camp could be moved without delay. Returning from this run, I shot a hawk (*Kaupifalco monogrammica*) from whose stomach we recovered a recently swallowed and quite undamaged example of the rather uncommon blind-snake (*Typhlops u. unitaeniatus*), the only one of its species procured during the trip. This elongated species reverses the normal pigmentation of creatures by being chrome above and uniformly black below.

The following week, having moved to Amboni in the meantime, I shot an eagle (*Circaetus cinereus*) which had swallowed four large snakes referable to three species, of which one was a night adder. The largest, a hissing sand-snake, measured quite four feet in length. In this way we continued to gather information about predators, prey and parasites, and our field-notes accumulated.

In due course I left Amboni for Magrotto Estate on Magrotto Mountain, which is close to the Usambara Range.

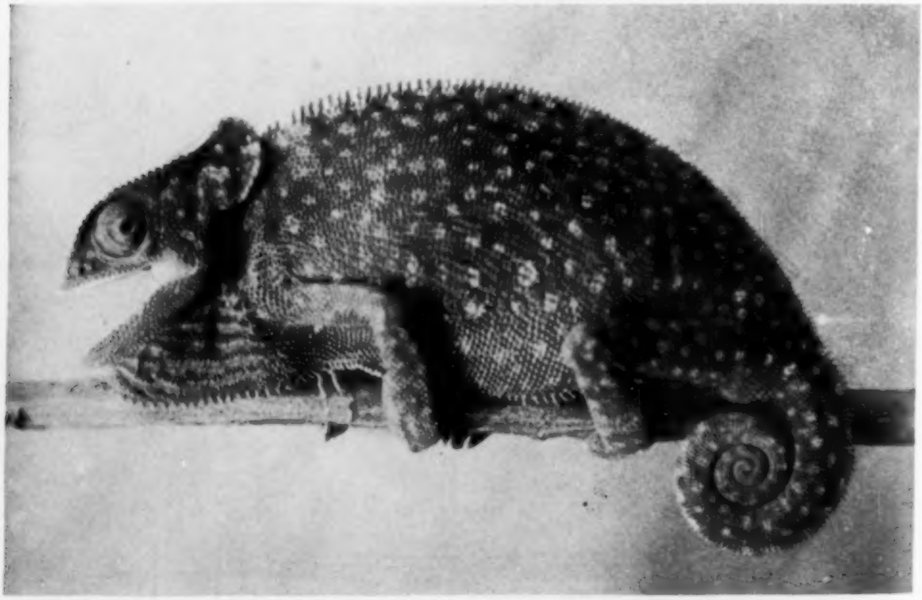
BABES AND BOTANICAL PURSUITS—A DAILY COMBINATION

DURING THE THREE-WEEKS STAY ON IDJWI ISLAND, THESE YOUNG PEOPLE VISITED OUR CAMP, THEIR PRINCIPAL INTEREST BEING TO WATCH MY WIFE ENGAGED IN THE TEDIOUS TASK OF CHANGING DRYING PAPERS IN HER PRESSES.

The lorry climbed the steep escarpment road with considerable difficulty, backing and filling at the hairpin bends which could not be negotiated in any other way. At 2,000 feet, or thereabouts, we ran into trouble, for heavy rain had fallen the night before and the wheels spun futilely on the slippery clay. After several such delays I walked on, expecting to be overtaken. An hour passed, however, so that I reached the hospitable home of the manager long before the lorry. Here Mr. and Mrs. C. Clausen asked me to tea and invited me to spend the night. I needed little urging, for wisps of fog were creeping about, and it seemed raw and chilly as a November day in England.

Next morning my host conducted me to a delightful camp site. It was on a crest situated in a semicircle of forest-capped ridges. The immediate vicinity was planted with oil-palms, for Magrotto is the only plantation of these palms in East Africa. With its well-kept terraced paths winding through the orderly lines of these ornamental trees, it gave one the impression of dwelling in a park or arboretum.

On arrival I had noticed beside the paths an occasional stone surrounded by the broken shells of the nuts—much as a litter of snail-shells lies about a stone which has served as anvil for some thrush. Later I saw that there was usually a small second stone nearby, a *pied de main*, as it turned out. For one day, when walking quietly back from a trip of investigation in the nearby forest, I heard the sound of intermittent tapping. Presently I descried a fat little darky, scarcely four years old, sitting on the path, his back toward me, guzzling the kernels, as he kept a more or less watchful eye on his mixed charges, a flock of sheep and goats which were feeding among the palms. Thus I realized how it came about that the plantation pickaninnies were so sleek and tubby.



A HANDSOME HORNLESS CHAMELEON, GREEN IN COLOR WITH ORANGE SPOTS
THIS CHAMELEON WAS NOT UNCOMMON IN THE EXTENSIVE COFFEE PLANTATIONS SOME MILES FROM CAMP ON IDJWI ISLAND IN LAKE KIVU.

AN EMIN'S WORM SNAKE FROM BUNDIBUGYO AND A BURROWING SKINK

THE FULL-GROWN, TERMITE-EATING REPTILE AT THE LEFT, IS OF THE SAME GENUS AS ITS NORTH AMERICAN COUSINS AND FORMS A LINK WITH EMIN PASHA WHO WAS ITS FIRST DISCOVERER. IN THE SECOND PICTURE, NOTE THE BUD-LIKE FORE LIMBS AND THE VESTIGIAL HIND LIMBS OF THE SKINK. THIS PROBABLY UNDESCRIBED SPECIES INHABITS SANDY SOIL WHERE IT COMES TO THE SURFACE BENEATH PILES OF ROTTING VEGETATION.

It was with regret that I started to pack up in preparation for leaving Magrotto. Not only was it the last camp of the trip, but it had furnished nearly fifty different kinds of reptiles and amphibians, and here the best oranges in the world might be had for a cent each, *i.e.*, 400 for a U. S. dollar! I had been starved for vegetables for the greater part of the tour, but while here the Clausens kept my table well supplied from their flourishing garden. 'Tis true that we had experienced much wet weather at Magrotto, but rain had fallen at least once during every week of the nine months occupied by the *safari*, so we had become almost indifferent to it.

The fourth, and final shipment of specimens for the States, making about a ton and a half in all, was turned over to the agents, and then the last two days ashore were passed at the Tanga Hotel, where my wife and I had stayed twelve years before on our return from the Usambara expedition. Now it was under the able management of Mr. and Mrs. Peter Roach, and as comfortable and well-equipped as any traveler could wish. Down the main road passed a company of King's African Rifles, equipped with the latest type of death-dealing weapons, such as Bren guns. As they returned from their route-march they sang some Kiswahili equivalent of Tipperary: it made one realize that we were back in civilization again! Germany was planning the invasion of Poland; Europe, it was rumored, was on the brink of war.

Next evening we boarded the *M.V. Dunbar Castle* which was to carry my Baganda to Kilindini and myself away from Africa. The *Dunbar Castle* which, within a few months, was destined to strike a mine and be sent to the bottom.

THE PERILS AND ROMANCE OF SWORDFISHING

THE PURSUIT OF *XIPHIAS GLADIUS* WITH THE TRIDENT IN THE STRAIT OF MESSINA

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Introduction

The swordfish is found in many waters the world around, and, because of the excellence of his flesh as food, is captured by many peoples using various methods. However, the chief instrument of his capture everywhere is the harpoon. In these harpoon captures there is much of romance, and because the fish is provided with a great broadsword—the most extraordinary weapon given to any fish—there is also peril in these encounters. This great and powerful fish was known to the earliest dwellers along the eastern and northern shores of that sea—the Mediterranean—which in classical times was well named "the sea in the middle of the lands." For in those early days the known world was practically composed of those countries which surrounded this great sea. These Mediterranean peoples knew, captured and ate this great fish. Furthermore, the Greeks being gifted with vivid imaginations, which were provoked by its lethal weapon, invented a mythical explanation of the origin of fish and weapon.

The Legendary Origin of the Swordfishes

That the *galeote*, or swordfish, was known to the inhabitants of the eastern Mediterranean many centuries before the Christian era is indicated by the romantic mythological story of its origin. It is alleged that when Achilles voyaged to Troy to aid Menelaus in seeking revenge for the abduction of his wife Helen, he went as leader of the Myrmidons. When Achilles had been treacherously slain by Paris, they rushed against the Trojans to avenge him. But when these refused to come out and join battle, the Myrmidons in bitter grief, sudden rage and blind fury threw themselves into the sea. However, Thetis, the mother of Achilles, took pity on them and changed them into fish; and since they were fighters, into fish that were allowed to retain their swords as long spikes projecting forward from their upper jaws—as swordfish.

The Swordfish and His Names

If there is any basis in this legend for a very ancient knowledge of the swordfish by the Greeks, it seems to be clear that from the very earliest times they regarded him as pugnacious and warlike. But turning from legend to fact, as Fig. 1 shows, this great and splendid fish is beautifully streamlined from sword-point to tail-tip and is built throughout on racing lines—even his dorsal fin has an elegant "rake." He is a living torpedo, evidently capable of great speed. With his broadsword-like bill he is surely armed for war and is aptly named "swordfish."

The extraordinary prolongation of the upper jaw attracted the attention of the ancients and surely led to their assigning characteristic names to the fish. The Greeks called him *Xiphias,* and the Romans *Gladius*—each name meaning sword. And we moderns have adopted both names and call this fish *Xiphias gladius*—thus doubly (in two languages, naming him the swordfish. But

FIG. 1. BROADBILLED SWORDFISH
AMERICAN MUSEUM MODEL OF MICHAEL LERNER'S RECORD ATLANTIC SWORDFISH—13½ FEET LONG AND 601 POUNDS IN WEIGHT.

since *Xiphias* has a long, broad, flat, smooth sword, he is called the *broadbill* to distinguish him from the *spearfishes*, the marlins and sailfishes, which have *round bills* with blunt tooth-like bodies on the under side of their relatively short spikes.

The cognomina given our fish all play upon the sword theme. His name in all languages is a translation of the word swordfish. These names are too numerous to list here, but it may be noted that the Italians call the fish *Pesce Spada;* while the French name him *Empereur, Imperator, Epée de Mer* and *Espadon*. And we to-day dub him the "ocean gladiator." All names go back to the fact that the fish bears a straight double-edged sword (Fig. 1), and it will be remembered that the Roman emperor was always represented with such a drawn straight sword in his hand. The swordfish found in the Mediterranean and known to the ancients is surely *Xiphias gladius*. And even as the Roman despot was supreme over the far-flung lands surrounding the Mediterranean, so *Xiphias* was supposed to rule over the watery empire of that sea.

Xiphias Given a Bad Reputation

The ancients, having given our fish his characteristic names, proceeded to assign him a character according. They gave him a "bad name" and attributed to him a choleric and pugnacious temperament.

Thus, earliest of all, Sophocles, the Greek tragedian (496–406 B.C.), speaks of our fish:

> What Fury, say artificer of ill,
> Arm'd thee, O Xiphias, with thy pointed bill?

And Oppian (172–210 A.D.) in his "Halieuticks" (the English version of his "*De Piscatu*") speaks of Xiphias as "the Swordfish armed for War," says that the "hardy Swordfish wields the threat'ning Blade," speaks of its "murd'rous Use," affirms that he is

"Extravagant in Folly and in Fear" and concludes that

> Nature her Bounty to his Mouth Confined,
> Gave him a Sword but left unarm'd his Mind.

And in another place, evidently referring to the fishermen who harpoon him, Oppian writes of Xiphias that,

> With impotent Revenge his useless Sword
> Assaults the Boats, and stabs the treach'rous Board.

This opinion seems to have been held by many other classical writers who record the attacks of Xiphias on vessels in transit. And it must be confessed that the combination of long sword, huge eye and large stout body do give our fish somewhat of a sinister appearance (Fig. 1).

This belligerent reputation persists unto the present day. Thus one writer (in 1854) spoke of Xiphias as having "a sword . . . of a temper like that of its owner, neither to be trusted nor trifled with." And the outstanding modern writer on our fish said in 1883 that "the pugnacity of the Swordfish has become a by-word." Another (and more recent) author speaks of the "choleric disposition" of Xiphias, and another writes that "It surely seems as if a temporary insanity sometimes takes possession of the fish."

From this it is plain that the modern, as well as the classical, writers have given *Xiphias gladius*, the broadbill, a "bad name," and it must be confessed that there is some reason to justify them in what they have written. However, as will now be shown, Xiphias is given a sword, not that he may avenge himself on those who seek with the harpoon to capture him for food, but for a more prosaic purpose.

The Sword of Xiphias Used for Getting Food

From far antiquity down to the present time it has been known that Xiphias feeds on the dolphin (fish, not mammal) and his kind. Thus, earliest of all, Oppian states that, "To crested Horsetails hungry Swordfish haste," but gives no hint as to how the dolphin is secured. Now the sword of Xiphias is not primarily a weapon of warfare but is given him as an organ of food-getting. He has a large mouth but no teeth, and it is only possible that by swimming rapidly and wide-mouthed into a school of small fishes, herring, mackerel, etc., such as he feeds on, Xiphias might engulf many. But he has been seen to rise in schools of such fishes and by falling sidewise among them to stun many. He is known also to slash with his sword right and left in a school, disabling scores of fish, which are picked up at leisure.

The swordfish has been reported sometimes to toss his prey in the air or to impale larger fishes on his weapon in true gladiatorial style. This has been recorded by at least one scientific man (Bennett, 1840) as a personally observed fact. He writes thus:

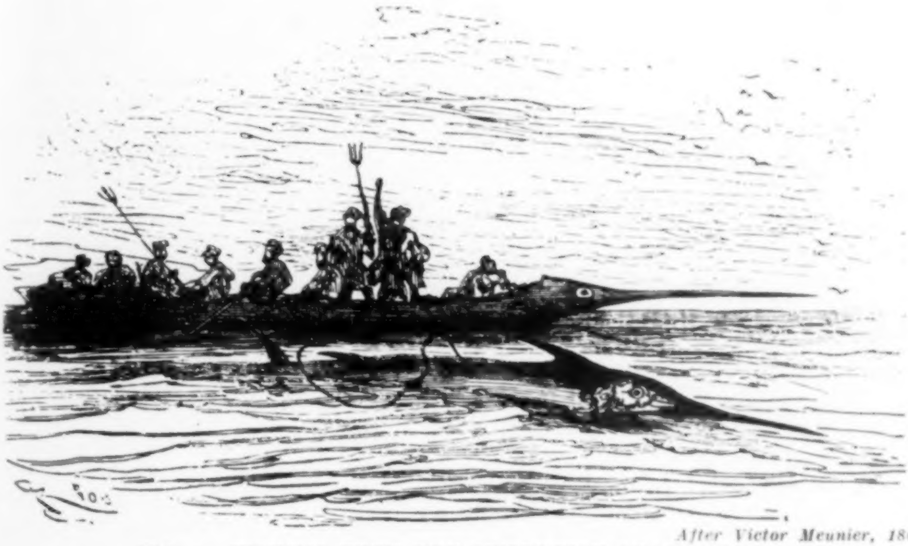
> The swordfish . . . subsists by making rapid darts amongst a school of . . . fishes, and after transfixing as many as possible on the beak or sword . . . shaking them off by a retrograde movement, or by moving the sword from side to side, and devouring them. I have seen a swordfish thus strike and devour three bonita, in a very dexterous and rapid manner.

This shows that Xiphias is an adept in the use of his weapon.

Xiphias Used for Food in Far Antiquity

Xiphias in turn is preyed upon by sharks and by man—by whom his flesh is highly prized.

If there is any basis for an early knowledge of the swordfish in the Trojan legend of his origin, then it seems probable that in far distant times Xiphias was used for food in the eastern Mediterranean. Of this we find evidence in the "Banquet of the Learned" of Athenaeus of Naucratis, an erudite Egyptian, who flourished about 200 B.C.



After Victor Meunier, 1868.

FIG. 2. FISHING WITH THE SWORDFISH-SHAPED BOAT

NOTE THE ELONGATE PROW CORRESPONDING TO THE SWORD, AND NOTE ALSO THE PAINTED EYE. THE OARS CORRESPOND TO THE FINS, AND THE RUDDER OR STEERING OAR TO THE TAIL OF THE FISH.

In the course of this banquet, which is reputed to have taken place in the house of Laurentius, a noble Roman, Athenaeus advises that the gourmand-traveler,

> Take a slice of swordfish when you go
> To fair Byzantium, and take the vertebrae
> Which bends its tail. He is a delicious fish,
> Both there and where the sharp Pelorian Cape
> Juts outward toward the sea.

Athenaeus was a prodigious and multifarious reader, and the great value of his book is that in it he has by copious quotations preserved large fragments of the works of ancient writers, which but for him would have been lost. Thus the above is a quotation from the Greek poet Archestratus, who lived about 350 B.C. and wrote a poem on "Gastronomy"—the major portion of which is lost. Archestratus lived in Sicily and must have known the swordfish in the Strait of Messina, since the Pelorian Cape is on the west side of the strait and only about eight miles from Messina.

I have introduced Xiphias to the reader and have briefly given somewhat of the "romance" of his legendary origin, of his names and reputation, of his use as food at least twenty-four centuries ago and of the normal use of his sword. And now the reader shall learn of some uses of his sword that justify the inclusion of the term "Perils" in the title. And, with old Archestratus, we shall look out upon that strait which had the rock Scylla on one side and the whirlpool Charybdis on the other. To these waters comes our great fish, in the words of an unknown writer:

> Fleeing from the northern countries,
> Comes the monstrous Xifia, proud
> Of its great sword, from Italy
> To the happy shores, and quickly
> Cutting the Tyrrhenian waters,
> The curved Pelorus doth approach.

Off this cape and in this strait, as for two thousand years past so to-day, the swordfish, called *pesce spada* by present-day dwellers in those parts, is eagerly sought for food. But first the reader and I will learn of the earliest fishing there for Xiphias for food.

Redrawn from a chart by courtesy U. S. Hydrographic Office.

FIG. 3. THE SWORDFISHING REGION OF THE STRAIT OF MESSINA. ON THE EASTERN SIDE NEAR SCILLA THE FISHING IS IN RELATIVELY DEEP WATER CLOSE IN SHORE. NORTH OF SCILLA AND IN THE SOUTHERN PART OF THE STRAIT ON BOTH CALABRIAN AND SICILIAN SIDES, THE FISHING, BECAUSE OF SHALLOWER WATER, IS FURTHER OFF SHORE.

The Earliest Swordfishing Story—in the Strait of Messina

The earliest of all the classical accounts of the perils and romance of swordfishing was written about 100 B.C. This comes from Polybius, the Greek historian of Rome. This part of his "History" is no longer extant, but fortunately it has been preserved by Strabo (63 B.C.–21 A.D.), the "Father of Geography." This fishing was in the Strait of Messina, at Scyllaeum on the mainland side. As will be noted, it is essentially the method practiced there to-day —two thousand years later—and the prototype of the practice of our New England and Nova Scotian fishermen to-day. Strabo's account is the very oldest on record and must be considered carefully.

> One lookout [on the rock Scylla?] directs the whole body of fishers, who are in a vast number of small boats, each furnished with two oars and with two men to each boat. One man rows, the other stands on the prow, spear in hand, while the lookout [on the cliff] has to signal the appearance of a swordfish. (This fish, when swimming, has about a third of its body above water.) As it passes the boat, the fisher darts the spear from his hand, and when [the staff of] this is withdrawn, it leaves the sharp point with which it was furnished sticking in the flesh of the fish. This point is barbed and loosely fixed to the spear [handle] for the purpose; it has a long end [of line] fastened to it; this they pay out to the wounded fish till it is exhausted with its struggling and endeavors to escape. Afterward they trail it to the shore or, unless it is too large and full-grown, haul it to the boat.

Surely this is romantic—the lookout on the high rock Scylla (about two hundred feet above the water), the little boats dancing on the waves in the brilliant sunlight, each with but two men, a rower and a harpooner, to tackle the great and much-feared fish. But there was peril as well as romance, and of this Strabo also writes:

> It sometimes happens that the rower is wounded [by the harpooned fish] even through the boat and such is the size of the sword with which the galeote [the swordfish] is armed, such is the strength of the fish, and the method of capture, that [in danger] it is not surpassed by the chase of the wild boar.

From this it is seen that swordfishing is an ancient occupation—having been practiced probably hundreds of years before Christ—and a dangerous one. This earliest known account of swordfishing, written by Polybius about 100 B.C., illustrates both the romance and the perils—two men (one armed with a puny dart) in a fragile cockle-shell of a boat in the strait between the dread rock Scylla and the even more dreaded whirlpool Charybdis, the whole outfit of men and boat weighing hardly more than the huge marine gladiator which they were attacking. Surely this fishing called for courage and daring of a very high order.

Fishing from the Galeote-Shaped Boat in the Mediterranean Sea

But as time and swordfishing went on

in this region, a new and improved method of taking Xiphias was perfected. The Roman writer Aelian, who flourished 120 A.D., gives the first hint of this most extraordinary fishing method. In his book on animals he says that when the swordfish has attained its full growth, "its sword may be compared to the beak of a trireme" (a galley rowed with three banks of oars). And when of this size that "it ventures to attack a vessel fashioned in the shape of [itself and] its own beak." This is but a hint, yet it indicates that the Romans of Aelian's day hunted Ziphias in a boat shaped like a swordfish (a galeote).

Not a hint but a clear statement is given by the poet Oppian (172–210 A.D.). After describing how Xiphias is taken on the hook (the earliest known reference to this method), Oppian goes on (in "Halieuticks," as translated by John Jones, Oxford, 1722) to describe the fishing from swordfish-shaped boats in the western Tyrrhenian Sea:

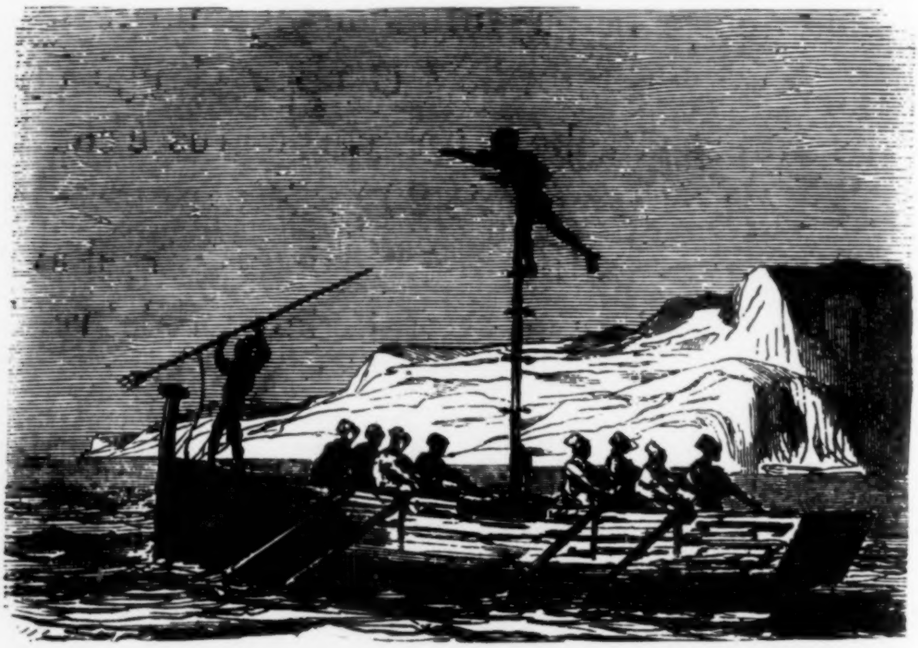
> The Western Gaul, Etruria's happy Swain,
> And whom Massilia's sacred Walls contain,
> Unusual Scenes of Strategem ordain.
> There vast enormous Lengths of Sword-fish glide,
> In Nature Fish but Monsters all beside.
> With mimic Form their Boats convex they bend,
> Display the Fins, the threat'ning Sword protend.
> The joyful Fish his new Companions greets,
> Herds with the Throng, nor sees the gross Deceits.
> The Silent Fishers form a Circle Round,
> The Trident dart and strike the triple Wound.
> Now undeceiv'd he feels the fatal Cheat,
> And struggles, fond of Freedom and Retreat.
> With impotent Revenge his useless Sword
> Assaults the Boat, and stabs the treach'rous Board,
> Wedg'd in the Wound; but soon the steely Blow
> Of Arms and Life at once bereaves the Foe.
> . . . .
> Like them the Boats familiar Shapes assume:
> 'Tis feigned Acquaintance brings the surest Doom.

The faint allusion to the shape of the boats in Aelian is here made very definite and clear. So, hoping that there might have come down from Roman times on painted vase or mosaic wall a picture of one of these swordfish boats, I have worked through many volumes on Roman antiquities, but no such picture has been found. However, I have found pictures of war galleys with rams in front shaped somewhat like the swordfish's sword and, in the region of the modern hawseholes, with eyes painted such as are found to-day on Chinese junks. Possibly these galleys were patterned after our swordfish.

One other faint reference to the Xiphias-shaped boat is found in a description of swordfishing off Scylla, dated late in the 1600's. Father Niccola Giannettasio, of the College of Reggio in Calabria, speaks of seeking the "Xifia" in the "painted boat" but gives no details.

Various modern authors refer to this ancient use of the Xiphias-shaped swordfishing boat, but only one goes into any detail. Victor Meunier in his "Les Grandes Pêches" (Paris, 1868) reproduces his artist's conception of this boat (Fig. 2 herein) and writes thus of this exceedingly clever and most interesting method of taking Xiphias:

> One of the methods in use among the Greeks consisted in employing barques modelled after the form of a swordfish, provided with a pointed prow which represented its [elongate upper] jaw, and painted in the dark colors which are peculiar to it. The swordfish approached [this boat] without mistrust, thinking that it saw a fish of its own kind [Fig. 2]. The fishermen, profiting by its error, pierced it with tridents. Although surprised, the animal defended itself with vigor, struck with its sword the planking of the deceitful barques, and often put them in danger [of sinking]. The fishermen took advantage of this moment to cleave the head of the fish and if possible to cut off the upper jaw. After having triumphed over the resistance of the fish and having possessed themselves of it, they lashed it behind the barque and brought it to land . . . This ruse was likewise made use of by the Romans. The fishing for the espadon was at that time one of the most important carried



After Victor Meunier, 1868.

FIG. 4. ANOTHER SWORDFISHING BOAT WITH MODERN ADAPTATIONS

THE STEM IS EXTENDED UPWARD TO THE LEVEL OF THE HARPOONER'S WAIST AND HAS A CROSS-PIECE OR REST FOR HIM TO LEAN AGAINST IN ROUGH WEATHER. THIS CORRESPONDS TO THE "PULPIT" OF AMERICAN SWORDFISHING BOATS.

on on the coasts of the Tyrrhenian Sea and of those of Narbonne in Gaul [bordering on the Mediterranean].

The faint allusion to the shape of the boat is made clear in Oppian's account and Meunier's figure (No. 2 herein), Here are the sword (ram), the eyes (like hawseholes), the fins (oars) and the tail (rudder or steering oar). When such a boat drew near to a swordfish, and when he turned a great eye upward, we can understand Xiphias thinking, "My big brother." Then, when he sidled closer, came the stroke of the trident, disillusionment, pain, anger and the return stroke against the deceiving boat.

Modern Swordfishing in the Strait of Messina

Swordfishing has been carried on off Scylla and all through the Strait of Messina since the days of Polybius, Strabo and Oppian. I have specific descriptions of such fishing under dates of 1673, 1798 and 1906 (two long accounts by Italian authors living at Messina). The methods described are outgrowths of those recounted by Strabo, showing a progressive perfection of technique. "After 2,000 years, this fishing remains just about the same, and the description of Polybius seems as if written yesterday." Brief descriptions with figures of present-day fishing may be of interest.

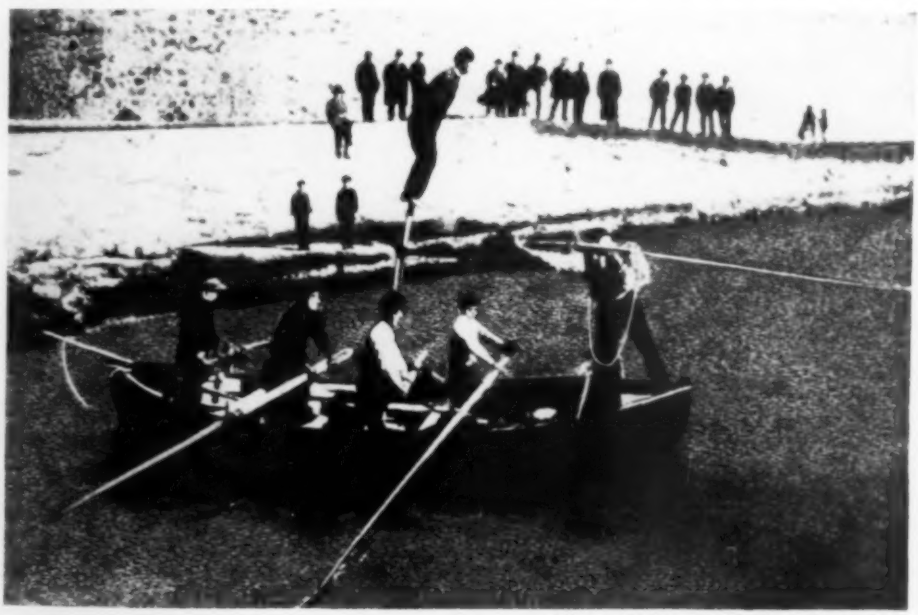
But, in order that the reader may have a clear idea of the "lay of the land," Fig. 3 is introduced—a sketch of the celebrated Strait of Messina, in which swordfishing has been carried on for over twenty centuries. On the mainland is Palmi, where the fishing begins. South of this is Scylla, at the eastern side of the entrance to the Strait, and on the west side, Punta del Faro (the Pelorian Cape). Further south is Messina on the Sicilian shore and Reggio

in Calabria. The fishing is mainly carried on in the waters thus delimited.

Under date of 1673, John Ray writes of the fishing that there are "Speculatores" on the cliffs of Scylla "to espy the fish," and there is an indefinite reference to the use of a tall mast in another book but no description of it. There are several oarsmen (number not stated). The greatest change from the simple method described by Strabo is found in the short mast (15–18 feet high) about the center of the boat, with cleats on it. On this stands another lookout, who takes directions from the "speculatore" where to find the fish, and so directs the rowers. When close on the fish, "he upon the mast comes down and taking the harping iron in his hand, if he can, strikes it into him. The fish being wounded, plays up and down and wearies himself," and the end comes soon.

By 1798 the technique of swordfishing in the strait had been so far perfected that it is almost identical with that described in 1906. Any differences in the methods of 1906 are simply refinements of those of 1798 and of 1673. The fishing off Scylla with its lookouts on the high rocks is of one kind. That on the lower Calabrian coast above and below Scylla, and always that off the Sicilian coast, is of another order. Each will be briefly described. But first it must be said that the fishing grounds throughout the entire strait are divided into "stations," to each of which one or more boats (of one company) are assigned. These in the beginning are determined by the lot, but to assure a fair chance to every boat or company, there is day by day a rotation of stations.

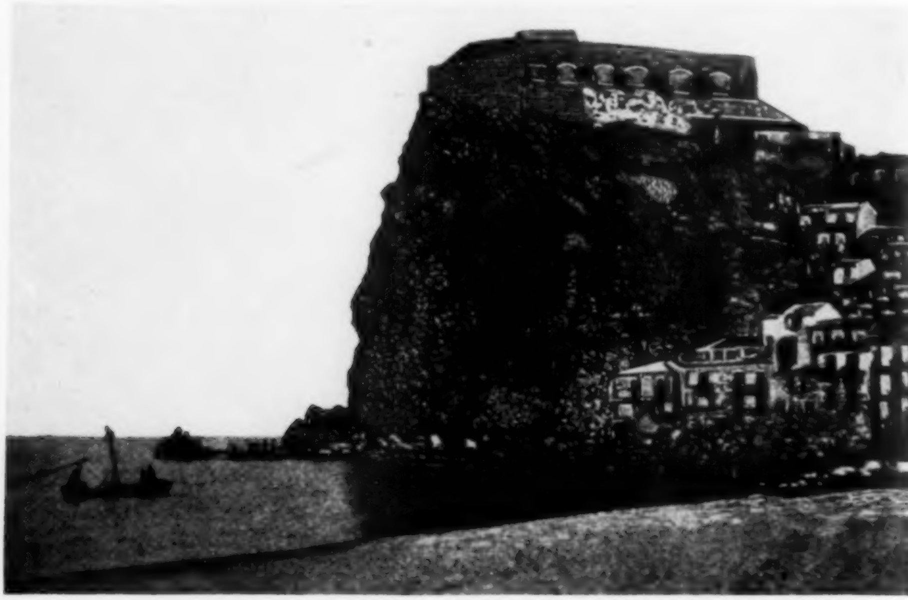
Before describing the technique of present-day fishing in the Strait, there must be interpolated here, under date of 1868, the figure and brief description



After a photograph by Mercadante, 1906.

FIG. 5. SWORDFISHING CLOSE INSHORE ON THE CALABRIAN COAST

THE BOAT IS DOUBLED-ENDED, THE OARS ARE OF UNEQUAL LENGTH; THE MAST-HEAD MAN DIRECTS THE COURSE OF THE BOAT, AND THE HARPOONER STANDS READY. ON THE NEARBY SHORE IS A GROUP OF INTERESTED SPECTATORS.



After a photograph by Mercadante, 1906.

FIG. 6. SWORDFISHING UNDER THE ROCK SCYLLA

THE FIGURE (MADE FROM A PHOTOGRAPH) SHOWS THE PROMONTORY, THE LITTLE TOWN ON ONE SIDE, AND ON TOP OF THE CLIFF AN OLD CASTLE. NOTE HOW CLOSE UNDER THE ROCK ARE THE FISHERMEN.

of a Mediterranean swordfishing boat unlike any described by any other writer on fishing for Xiphias in this sea. This is from Meunier, the French author elsewhere referred to. Apparently it was used in his time (1868), whether in Italian or French waters is not stated, but presumably off Italy. The boat is shown in Fig. 4, in which is seen what may be the forerunner of the rest or "pulpit", which is such a characteristic feature of American swordfishing boats. It is for this reason that this figure is inserted. However, strange to say, no trace of this remarkable "rest" can be found in recent figures of the fishing boats used in the Strait.

This boat is about twenty-five feet long, has a gunwale about forty-five inches above the water, a mast about eighteen feet high for the lookout, is wide enough for two oarsmen to sit on each thwart, and has a wide square stern. But most different from any other boat figured, is the fact that the stem is extended vertically upward and has at its top a crosspiece as a *brace* or *rest* at the level of a man's waist, against which the harpooner may steady himself in case of rough water. The crew is composed of eight oarsmen, the lookout and the harpooner.

Present-day Fishing off Scylla

The fishing here is done fairly close inshore. Lookouts ("speculatores") are stationed on the high cliffs overlooking the water or, if the shore is low, on towers varying in height (according to the elevation of the ground on which they are erected) from 80–150 feet above the water. Thus the land lookouts have before them the water of their respective stations or zones, which they ceaselessly scan for the fins of Xiphias swimming at the surface. The boats

are double-ended, and to facilitate rapid steering, so that the *pesce spada* may be easily followed in his "tours and detours", the oars are of different lengths—two long and two short. The long oars for ease of manipulation have outrigger oarlocks. In the center of the boat is a small mast (15–18 feet high) called *garrière*, having nailed to it cross-pieces by which the mast-header ascends and stands on a little platform near the top. Such a boat is shown in Fig. 5.

The crew is composed of five or six men—three or four oarsmen, a lookout and a harpooner; but when there are six, the lookout (when the fish has been struck) descends and aids at the oars, pulling on one and pushing on another, to facilitate rapid turning to follow the fish in his "vertiginous course."

The lookout on shore by voice and by the waving of a white flag indicates where the swordfish is. The masthead man (*farière* or *filière*) directs the rowers how to follow the fish. The short oars are rowed steadily, but not so the long ones. One oarsman pulls forward, but the other backs (they are both aided by the extra oarsman), and thus the boat is turned in a very short radius. In this way the boat fairly easily follows the erratic movements of the swordfish, which seems almost to play hide and seek with the boat.

The special shape of the (double-ended) boat, the inequality in the lengths of the oars and the technique evolved in their handling, have brought it about that this boat has great speed as well as great manoeuverability, and have led to its being called *bersagliere del mare*, the "swift scout of the seas." When brought within twelve or fifteen feet of the fish, the harpooner may "pitch-pole" his harpoon with a slightly curved trajectory (Fig. 5), or if "put onto the fish", may strike it at short range (Fig. 8). In any case the stricken fish tires itself out dragging the harpoon shaft and long line behind it, and is then hauled up to the boat and killed. Sometimes, however, the shaft is retrieved by a warp tied to it.

This is a fair description of the method of fishing at or near Scylla. But Scylla is not the naked promontory it was in Strabo's or in Oppian's time. Tradition has it that on it there was once a temple to Minerva, but more worthy of belief is that in 1255 it was fortified by the viceroy of Sicily. Today there is a castle on the cliff and under its shadow fishing is still carried on, as may be seen in Fig. 6, made from a photograph.

Following on the rather technical description above, the following quotation from Mercadante (one of the Italian authorities referred to above) will bring

FIG. 7. FISHING IN SHALLOW WATER OFF LOW SHORES IN THE STRAIT. NOTE THE *felucca* OR LOOKOUT BOAT WITH ITS TALL MAST (*antenna*) AND LOOKOUT OR *antennière*. NEARBY IS THE *luntro* OR PURSUIT BOAT WITH ITS SLEEPY FISHERMEN.

the whole scene—especially in its romantic aspect—before the reader. It is dated 1906.

The view, . . . during the sword-fishing season, is a spectacle unique in its kind, which is well worth seeing. There is the long line of fishing boats, each moored to its own buoy, at a right angle to and not far from the coast-line (Fig. 5). Squatting in each boat are the fishermen, unmindful of the burning rays of the sun. From time to time, they turn their eyes to the mount from which their lookout scrutinizes and examines the whole extent of the sea which his view includes; then they turn burning glances of pique or envy toward their nearby companions, more fortunate because of a fish having appeared in their section of the sea.

On high, the lookouts, in the midst of the thick green of the trees or vineyards, appear like dolls when viewed from the sea. Now from one, now from another, come cries to direct the fishermen. These, all anxiety, bend over their oars and row with all their strength, obeying the *filière*, who, from his little mast in the boat, directs their movements, inciting them with the words *Tuttu paru, tuttu paru, vò!* (Straight ahead!). While from the lookout come the same cries, accompanied by wavings of his banner.

The fish appears on the surface of the sea, only to disappear and presently to reappear in the waters of another post. The men and boat of this station joyfully take up the chase in their waters. Then follows the slow return to its own post of the unlucky boat deserted by the fish, since it is forbidden to follow the fish into the station of another boat where it has reappeared and to which boat it now belongs.

All these things contribute to the anxiety and agitation, not only of those who take part in the hunt, but of the disinterested spectator who is merely an onlooker and watcher of the fishing.

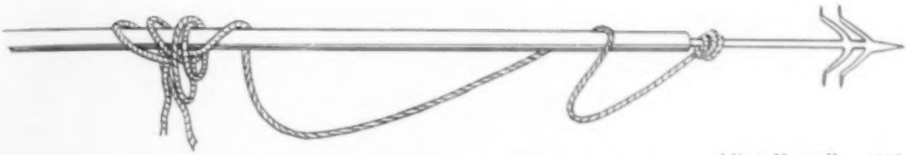
Present-day Fishing off Sicily

Even more off the Sicilian coast than off Scylla, the pursuit of Xiphias is a hunt, since the fish has opportunity to range more widely. This is due to the fact that the shores are somewhat low and the water shallow, and hence the

After Mazzullo, 1906.

FIG. 8. HARPOONING THE PESCE SPADA FROM THE LUNTRO

THE *antennière* HAS LOCATED THE FISH, THE LOOKOUT FROM HIS LITTLE MAST HAS PUT THE *luntro* ONTO THE FISH, AND THE *farière* DRIVES HOME THE TRIDENT.



After Mazzullo, 1906.

FIG. 9. THE DELPHINERA, DRAFFINERA OR TRAFFINERA

THIS IS THE MODERN TRIDENT USED IN TAKING XIPHIAS IN THE STRAIT OF MESSINA. THE WINGLETS ARE HINGED AND ARE SET IN PAIRS AT RIGHT ANGLES. WHEN IN THE FISH'S FLESH THEY OPEN OUT AND FORM TWO DIAMETERS, SECURELY HOLDING THE FISH.

fishing is done farther out. Here and in other posts of the strait where the hills are low or are some distance from the shore, there has been evolved a very ingenious modification of the ordinary method of fishing. There must still be a lookout with an extensive field of vision. This is secured by erecting on a large boat (a *felucca*) a high mast called an *antenna*. This mast (Fig. 7), which is sixty to eighty feet high, is secured by lines reaching from its top to the sides of the vessel, after the fashion of the shrouds in a sailing vessel. Dependent from the top and fastened at the bottom is a rope ladder by which the lookout, or *antennière*, ascends to his platform near the top of the mast.

From his perch at the masthead of the lookout boat, the *antennière* gazes down on the sea as on a mirror. Nearby is his own fishing boat, and in the distance are other lookouts and fishing boats. When all is serene, all is romantic; but even then a four-hour "trick" in the broiling sun, with no fish in sight and with nothing but at best lukewarm water to drink, largely takes away the romance. But when the wind rises accompanied by a swell, and his uneasy perch swings through an arc of 40° or 50°, his position becomes perilous in the extreme. He must hold on "by his eyelids," as the sailors say.

Attending the lookout boat, or *felucca*, are one or more fishing boats generally called *lontro* or *luntro*. Each has four to six men as a crew. When no fish are in sight, these men sit sleepily in the hot sun, while one man (probably the captain) unfurls an umbrella (Fig. 7). However, when the lookout sights a fish, all is activity and the method followed is that described above and indicated in Fig. 8, in which the harpooner is ready to drive his weapon into the *pesce spada*. When he strikes a fish, the harpooner shouts, "Hail, blessed Saint Mark!"

Of special interest is the peculiar harpoon used everywhere in the strait, and called *delphinera* or *draffinera* or *traffinera*. This consists of a wooden shaft about twelve feet long, furnished with a curious steel head. In this the central shaft is continued in a median point or spike, but on either side are two, and sometimes four, winglets. Fig. 9 is made from the colored cover of one of the 1906 brochures on swordfishing in the Strait of Messina. This, unfortunately, does not show that the four winglets are *hinged*. But so they are—this in order that they may lie close to the central shaft and point upward when this harpoon is driven into the flesh of Xiphias. When there are four earlets or winglets, the pair nearer the point of the delphinera are shorter than those higher up. This pair is set at right angles to the other pair and when opened up the points are seen to form two diameters at right angles. When this curious harpoon is driven in the fish and the line tightened, the winglets open out and most securely hold the fish.

Attached to the harpoon head is a line, the *protese*, often six or eight hundred feet long, with which to hold the fish while it tires itself out. Sometimes the

shaft is dragged about by the wounded fish, but generally it becomes detached and is drawn to the boat by a warp. The retrieving of line and fish is generally done by a second boat, while the first returns to the battlefield to hunt for another fish.

Greek Influence in the Messina Fishery

Until the very recent past there survived in the Messina fishing certain reminiscences of a very ancient Greek origin of the method of taking Xiphias. These undoubtedly came about as follows. The Greeks migrated to and settled in Sicily and Southern Italy as early as about 800 B.C. As time went on, their trading colonies grew into cities (Agrigentum, Crotona, Messana, Neapolis, Rhegium, Tarentum, etc.), and this section of Italy was called Magna Graeca. Quite surely they brought with them from the east a knowledge of the fish they called Xiphias, and certainly they hunted him in the Strait of Messina long before the Christian era. Presumably they originated the trident fishing and passed it on to the Romans. This Greek influence is found in certain words and sentences used in the fishing. Of this Brydone wrote in 1773 that:

> The Sicilian fishermen (who are absolutely superstitious) have a Greek sentence which they make use of as a charm to bring the swordfish near their boats. This is the only bait they use and they pretend that it is of wonderful efficacy and absolutely obliges him to follow them; but if unfortunately he should overhear them speak a word of Italian, he immediately dashes deep under water and will appear no more.

To-day the swordfishermen have a specialized code of verbal signals by which the lookouts direct their boats. Even until about 1900 (Mazzulo, 1906) these same signals were given in Greek. The idea was that Xiphias was lured by this siren song in Greek (his native tongue, so to speak) and held a spell-bound victim for the trident. But should he hear a word of Italian, the spell would be broken and, faster than the harpooner's arm, he would make off, to return no more. To-day, however, the "tongue" has undergone a complete reversal, for now the people of the lower class jokingly say that they speak in Greek so that the fish will *not* understand and hence not run away.

The Perils of the Messina Fishing

Swordfishing or, more properly, swordfish hunting, is such a romantic undertaking and such good sport, demanding much skill and strength, that famous warriors, princes and even sovereigns have come to the Strait of Messina to engage therein. And undoubtedly Xiphias has retaliated hundreds of times by attacking the boats of his persecutors. Indeed, every describer of this fishing who has been consulted so says in general terms. But with one exception, specific accounts are unfortunately lacking.

However, it is related that while Don Juan of Austria was waiting at Messina for the fleet with which a few months later he defeated the Turks at Lepanto (1571), he became so enthusiastic and skillful a harpooner that he killed six swordfish. But one of these, "not very much resigned to die, launched itself against his boat and pierced it from side to side." The prince saved the sword and sent it to his father as a memento of his experience.

BIOLOGY AND HUMAN AFFAIRS

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I

At the present stage of human history when Europe has been teetering between peace and war, and has finally taken the plunge into the abyss; when Japan is laying waste the land of a peaceful people and millions of innocent lives are being snuffed out; when unemployment in the United States is still wide-spread and industry is staunchly opposed to the punitive, discouraging measures of the Federal Administration and its open-handed spending; when the entire world seems unsteady, uncertain and bewildered about the right course to pursue, it may be desirable to forget economics, armaments and psychology temporarily and to focus our thoughtful attention on man, the animal.

Given man as he is, can we expect a better order of things as a result of his planning and organizing ability? Or has the world always been beset with problems—sometimes great, sometimes small, but always present and always undermining or jeopardizing human security and happiness? Can we expect that order of things where "peace on earth, good will toward men" will be the permanent guiding philosophy in human relations? Or must we learn to accept the point of view that man, by and large, is grasping, selfish, envious of his neighbor's possessions and anxious to achieve power and importance or their equivalent in the form of great wealth? It is desirable to investigate some of these fundamental questions in order to find new light and wisdom in seeking their answer.

To the great majority of human beings the fundamental relationship and affinity of man to the other forms of life in the universe is either unknown, ignored or forgotten. Darwin's theory of organic evolution has been ignored almost entirely except as a concept to be considered briefly in classes in biology, without any relationship to human living, and then to be promptly forgotten. Very few persons are conscious of the inexorable fact that man is endowed at the time of birth with certain potentialities, beyond which he can not go. A favorable environment will help to bring these potentialities to fruition, but the best environment will never endow an individual with qualities he does not possess.

The human being is like an exposed photograph. The picture is there in the negative and can not be altered. That is the contribution of heredity. The type of developer used and the expertness employed will determine the character of the resulting picture. That is the influence of environment. It is therefore erroneous to assume that all men are born equal. They are equal before the law, but they are vastly different in their endowments and potentiality. Some will be leaders, while the great majority will be followers. Some will be scientists, inventors, teachers, engineers, physicians, lawyers, bankers, business men, publicists, statesmen, etc., while the great majority will be artisans of one kind or another, pursuing the more humble occupations of life. That is natural law. It has always been thus from time immemorial, and there is no reason for believing it will ever be otherwise.

The aim of organized society should not be to bring all humans to one level. That is anti-biological. It will not work. Russia tried the experiment and had to

abandon it. Innate differences in human beings must be recognized and developed for the best interests of society. The aim of organized society should be to provide an equal and satisfactory opportunity for every one at birth in order that every individual may attain the maximum development of his potentialities. If this could be achieved, a state approximating Utopia would have been attained. But alas, even this desirable and theoretically feasible state is difficult of actual achievement.

II

The law of nature is for one form of life to live at the expense of another. It is universal throughout the animal kingdom from the lowly amoeba to exalted man. The amoeba surrounds and devours the bacterial cell and other forms of living and lifeless organic matter. The beautiful song-bird which gives so much human satisfaction lives on earthworms and insects, when it can get them. The cat crawls along never so quietly and cautiously to capture the song-bird unawares and to still its pretty song and make its body part of itself. Dogs and cats are generally instinctively unfriendly, although they do not devour each other. The lion, the tiger, the leopard, the wolf, as well as other beasts of prey, live on smaller and weaker animals in their environment. Large fish live on smaller fish; large, predatory birds like the hawk feed on smaller, harmless feathered animals. Everywhere throughout nature, one form of life exists at the expense of another. That is the law of the living universe. He who has scruples about eating living things, animal or vegetable, soon ceases to exist.

Man is the most efficient of all animals in insuring for himself a constant supply of food. He has domesticated animals to furnish him milk and eggs and meat. He has learned to grow various grains to insure a constant supply of breadstuffs and cereals. Now he cultivates fruits and berries, vegetables, sugar-cane and sugar-beets. He has learned to make butter from cream and to preserve food indefinitely by adequate refrigeration, by canning, by drying, by pickling and by various other methods. The revolving seasons of the year do not bring fear and want on the one hand, nor joy and plenty on the other. Through rapid means of transportation coupled with adequate refrigeration fresh foods are now available in the north temperate region at all seasons of the year. And even if these facilities should fail temporarily, canned foods and other preserved foods are available at all times. The specter of starvation has been virtually banished in this country and in other progressive areas of the world.

Man has insured his essential means of sustenance by using his superior brain. But his supremacy must be demonstrated every day of his existence. Eternal vigilance is the price of safety against bacteria and other microorganisms as well as rodents who vie with man for the possession and use of his foods. Milk is pasteurized in order to make it safe for human consumption. Water supplies are filtered and chlorinated so that typhoid fever germs and other intestinal bacteria may be eliminated or rendered innocuous. Most foods are consumed after thorough cooking, partly to make them more digestible and partly to render them free of harmful bacteria, protozoa, worms and other parasites. The world belongs to man because he has demonstrated his superior ability to survive in the conflict with all other living things and for no other reason.

III

In this wonderful world, with its revolving seasons; with the sun, the moon and the stars; with an atmosphere that is not too cold nor too hot for survival, and which contains the precious oxygen so vital to life; with the birds, the trees,

the flowers, the mountains and the seas, the rivers and brooks and all that goes to make the earth beautiful and wonderful, there is probably no other living thing as remarkable as man himself. Man alone can stand off and wonder about the mystery of life and the universe. Man alone can ask himself the question, "Where did life come from and whither does it go when it departs the human or animal frame?" It is man who can write poetry and immortal literature and preserve them to the end of time in spite of dictator conflagrations and other acts of barbarism. It is man who has written great symphonies and lyrical songs and who has created works of art of immeasurable beauty and soul-satisfying quality. It is man who has conquered the forest and jungle, the great vastness of the oceans and the atmosphere and the hazards of swamp, mountain and great distance. It is man who has spanned rivers with beautiful, majestic, lace-like networks of steel and who has burrowed under rivers and through mountains in order that he might pass quickly and safely from one place to another. It is man who has built reservoirs to guard against drought. It is man who has developed the telephone, the radio, the telegraph, the internal combustion engine and the enormous system of paved roads that link every city and hamlet together in a sense of friendly intimacy and nearness.

These are some of the great achievements of man in the control of his environment. Other achievements are equally great. The establishment of the germ theory of disease and knowledge concerning the sources of infection and their modes of transmission have made it possible for man to enjoy healthy living to a degree never realized before. The average life span has been prolonged, and great suffering and loss of precious human lives have been prevented. It has been a remarkable demonstration to show that flies, mosquitoes, fleas and lice may transmit serious and fatal diseases to man. It has been a great achievement to discover vitamins and to demonstrate their importance and the importance of minerals in human and animal nutrition. Modern science, which must still be regarded as being only in the infant stage of its development, has transformed the universe for man and made him master of its temporal destiny to a greater degree than ever before. Science has made it possible for man to save human life, prolong its usefulness and make it more secure. The abuse of science has brought in its wake sorrow and misery, war and destruction, and terror and anguish beyond human credulity.

IV

It is this conflict between the dual nature of man that merits further analysis. It is as though man were capable of living two lives—one devoted to enhancing his welfare, the other designed to injure, to exploit and to destroy. One is a realization of his dream life, where all men are noble and worthy of assistance; the other, the realistic interpretation of life, that man is an animal and that the fittest and strongest must survive at the expense of the weak. Probably there is no species of life on the face of the earth other than man in which the dream life and the realistic life, the benevolent life and the cruel life, are practised simultaneously with such a high degree of perfection. Not only is one nation or group of nations arrayed against another, but the suspicions, antagonisms and hatreds between races, between different religious sects, between people of different color are too well known to require further elucidation. This is true even in the twentieth century, when time and space have been nullified to a large degree and when education and enlightenment are supposedly more wide-spread than ever. Even in the United States, the melting pot of the entire world and a country

of boundless resources and a very high standard of living, the fusion of the various elements can hardly be said to have occurred successfully.

True, there are numerous exceptions. There are many (numerically but not proportionately) who have risen above class and creed and color and who live harmoniously and happily with the representatives of other races, nationalities and religions. But the majority simply tolerate those who are different and consequently are easily susceptible to propaganda or education designed to foment trouble. The campaign against the Jews in Germany in recent years has had its repercussions in every quarter of the world. Even the United States and Great Britain have not been uninfluenced by it. The difficulty of placing young college men of unacceptable nationality, religion and color in industry and the professions is too well known by those who have tried to do so. It is questionable whether these innate antagonisms can be extirpated by either force or education, for they would seem to have a biological basis. Those rare, high-minded individuals who have risen above class, nationality, creed and color must be different. They are endowed at birth with the elements that make for magnanimity, for charity, for tolerance, for affection to one's fellow men. But even in these individuals, the antagonism toward others is often not entirely eliminated, but simply modified in greater or lesser degree.

History is replete with instances of the noble dream life of men on the one hand and the cruel, remorseless, realistic life on the other. No one group of people, no one creed, nationality or color has a monopoly on one over the other. Jesus of Nazareth is doubtless the outstanding character in Western civilization who preached and lived a life of love toward his fellow men. He dreamed of a human society governed on the basis of love and ethical behavior. But he was persecuted by his contemporaries as a dangerous individual and finally crucified. For almost two thousand years his spirit has moved among men, urging them onward to the dream life he envisioned, but alas, we seem just as far removed from its attainment, in spite of millions of sermons urging us onward, as we were when He was alive. Other great spirits have motivated the Moslems, Hindus and Oriental peoples to similar heights of human behavior, but always with the same frustration.

It may be argued that the world would be poorer spiritually and in a worse state physically without these great religious leaders. That may or may not be so. We shall never know. The fact is that we can not divorce religion in its ethical and spiritual aspects from our daily lives, for that kind of religion is necessary for mental and physical health and that kind of religion is the only means available to man to bring the dream life into organized society.

Those who remember Woodrow Wilson's heroic measures to keep this nation out of war, and to whom the dream life of a better world is still a stirring challenge, will thrill at the recollection of such phrases as "A man may be too proud to fight" and "Peace without victory." Later, when he was forced to lead this nation into war against the Central Powers it was "To make the world safe for democracy." True, he was determined to use "force without stint or limit" to achieve his end, but his aim was not territorial or material aggrandizement. His aim was to release the German people from the fetters of an imperialism that bound them and made them helpless and prevented them from living at peace and on friendly terms with their fellow men. Military victory he achieved, but alas, at the very moment when his dream life was about to be realized, he was thwarted at home and abroad and a realistic conception of life was substituted at the Peace Conference. The "heart of humanity beats under common jackets," he said, but the

brains that govern and rule humanity still function in the bodies of realists adorned in morning coats.

Rarely is anything entirely white or black in human relations. Usually it is a compound of both, with varying degrees of blackness and whiteness. Life is replete with instances of noble behavior and with efforts to grasp and hold the vision of the dream life even for a brief, fleeting moment. The horrors, barbarities and cruelties of the World War were tempered by innumerable acts of courage and heroism, by assistance to dying or injured comrades, by self-sacrifice even in order to salvage or protect something beautiful and holy or somebody who meant more than life itself. The psychology of the time was self-sacrifice for a cause, for an ideal more precious and beautiful than mere mundane existence. It was an ideal that appealed to youth. That was the dream life come true. The end of the war brought in its wake disillusionment and frustration. The realistic philosophy of life was once more to the fore.

In the field of public health the opportunities to live the dream life are possibly greater and more frequent than in any other field of human endeavor. Unfortunately, public health work is usually not associated with spectacular displays which arrest popular attention and stimulate human emotions. The physician who relieves aches and pains has contact with human beings who honor and adore him and who tell the world of his greatness. The surgeon who explores the recesses of the body and cheats death of its victim is recognized as a human savior and is universally proclaimed. But the health officer or engineer who purifies a polluted water supply capable of dealing death and destruction to thousands, or who builds sewers and plumbing systems, or who sanitates and pasteurizes the city milk supply, or who insures the safety of the food supply, or who drains swamps and controls mosquito life, or who purifies the atmosphere in the home, in the factory and in the community or who does any one of a number of other things which make for human health and comfort, he remains unnoticed and unsung. The effectiveness of his efforts is reflected merely in lower community death rates and in greater longevity. His contribution is to the entire community and not to any specific individual, and hence he is not acclaimed as a great public benefactor except perhaps posthumously and on rare occasions when he has completed twenty-five or fifty years of continuous, poorly remunerated service.

The better qualities resident in man are always stimulated during periods of emergency. Witness the thrilling rescues at sea during storms and at great hazard to those happy to be chosen for the task. Every human heart thrills to the rescue and relief work performed during flood, fire, hurricane, earthquake and other catastrophes. It is a privilege and pleasure to give on such occasions if one is unable to serve. Witness, too, the constant support of the needy, the care of the sick poor, the protection of the aged and the feeble, the veneration of womanhood and motherhood, the lending of a helping hand or a kind word in all the daily walks of life. During the recent depression, when millions were unemployed, no one in the United States was allowed to starve or to freeze to death. These are all instances of the nobility inherent in all humans, of the realization of the dream life on earth. There are few, indeed, who are so calloused and disillusioned that they do not respond to the vision of an ideal society, where men will love one another, where war will be banished forever, where want and misery have disappeared, where all will be equal and live in happiness. The sermon, the play, the lecture, the article that portrays this ideal state stimulates more joy in the human breast than any other form of intellectual message. Man has a yearning for Utopia and in his dream life will ever strive to attain it.

He may be frustrated and disillusioned again and again, but he will never live long enough to cease to thrill to its inspiring stimulus. We are all like children, and we carry our love for fairy-tales and miracles, in one form or another, down to the end of our days.

The realistic aspect of life in human society is, alas, only too apparent on every side. The struggle for supremacy among nations and among individuals is one of the saddest of human spectacles. In 1914, Germany practically controlled the world, but she was not satisfied until she possessed and dominated it as well. Her ships traveled to the four corners of the earth. Her industries commanded the greatest respect and admiration everywhere. Her art, music, literature and culture were renowned. Her universities and research laboratories were the mecca of students and scientists and the envy of everybody. She was rich. She was powerful. But something innate in her protoplasmic composition, something biological, made her want more.

Within other nations the picture is essentially similar. Wealth is poorly distributed. Some persons are fabulously rich, while others are incredibly poor. Some are greedy and avaricious and take more than their just share of this world's goods. Those men who received fabulous bonuses in 1929 and 1930, sometimes as large as $1,500,000 and $1,600,000 in addition to a handsome monthly salary, were taking more than they deserved. Such men, it was said, were supermen. They could get business for their companies where ordinary individuals could not. The depression years exposed that fallacious theory. The supermen became mere ordinary individuals. The machinery in their industries did not function more actively than in others. They could not manufacture orders when orders were not available.

The publication this year of the ridiculously exorbitant salaries paid to the producers, actors and other appendages in the moving picture industry in the United States indicates the existence of a racket which will have its day of reckoning. Can the relative contribution to the welfare of society of professors, research scientists and professional workers generally be determined by their annual earnings in comparison to those obtained by the moving picture czars and their appendages and by Big Business generally? Or does one's nearness to the bulging money bags determine in a large measure how much one gets?

Another instance of realistic living is found in the lives of the racketeers in the United States. They are the modern version of the Jesse James boys, who looted and intimidated and killed to get something for nothing. The bootlegger was a disgrace to our finer traditions during prohibition days. The industrial racketeer has terrorized thousands, killed when necessary, extorted toll from both labor union and employer. There have been poultry racketeers, laundry racketeers, bakery racketeers, fur racketeers, clothing racketeers, etc., *ad infinitum*. Always it was easier and safer to pay tribute and to keep quiet than to do something about it. It was only when community decency became outraged at this open rape, and when by good fortune those in political power happened to be on the side of decency, that some of these rackets and racketeers have been brought to term. The fact that racketeering is a recurring disease leads one to suspect that it is reasonably wide-spread, that it never dies out altogether, and that it becomes active once more in a given community when the conditions are favorable again.

One would suppose that the realistic life would at least be absent in the field of religion, but that this is not so is apparent to the informed. When a professional traveler returning from Mexico reports that in a town of less than 10,000 inhabitants there were so many churches of one denomination that an individual could go to a different one

every day in the year and not exhaust the supply, one wonders whether the church is more interested in serving its adherents or promoting its own physical well-being, especially as poverty and ignorance are wide-spread among the people. The same traveler reported that the ornaments and decorations in the cathedral of Mexico City represented fabulous wealth. One must not be condemned as being anti-religious or anti-church to give expression to such obvious materialism at the expense of human welfare. If revolt to such injustice has occurred in other sections of the world where such conditions have been duplicated, it is at least understandable.

Witness also the rabble-rousing behavior of a radio priest. Using innuendo, spreading misinformation or half-truths as the whole truth, asking suggestive questions instead of making definite statements, this self-appointed guardian of human liberty and champion of the common man flays communism and whips up the emotions of his listeners against innocent people and sets up bogies to serve as smoke screens for the thing he desires earnestly to protect. Why does the radio-priest flay communism so methodically? Is there danger of communism here? Is he afraid his church will be discredited here as elsewhere? There is no need for this fear, if the church is ethical, if it is not too grasping, and if it caters to the physical as well as the spiritual well-being of its people. If we can not expect to find the noble life among those who wear the cloth of the church, where shall we look for it? It is of course true and well known that all religions abound with noble selfless leaders. They add beauty and love and aspiration to the daily lives of millions.

Even the fields of public health and education are not free of the poisonous virus of the realistic life. Teachers and matrons in the public school system have in some instances been appointed only or largely from one nationality and religion. School physicians employed on a part-time basis have not visited the schools under their supervision for years, but have had an understanding with the school principals to call only if a card were exposed in the window. Public health nurses in some instances have been appointed without adequate preparation and training and have functioned without supervision. Tuberculosis hospitals have served as free board and lodging institutions to large numbers of individuals, presumably tuberculous, who would enter in the fall, with the approach of cold weather, and depart in the spring when the weather was milder. The appointment of untrained sanitary inspectors in health departments from the politically deserving has occurred with astonishing frequency. Experience proves that public health and public education are sometimes used and extended as a means of distributing the wealth more equably and as a means of giving jobs to the "deserving."

V

The foregoing facts portray very clearly the constant struggle between the effort to achieve the dream life in organized society and the realistic life that counteracts, retards and nullifies it. For two thousand years of recorded time, and more, this struggle between good and evil, between tolerance and intolerance, between understanding and lack of understanding, between love and hate, between charity and greed has been going on. Education, religious instruction, science, engineering, economics, sociology, psychology have not succeeded in bringing about a solution. The reason, perfectly clear from a biological standpoint, is that fundamentally man has not changed. We have placed our faith first in one system and then in another and have always experienced failure. No system which man can devise can take the place of integrity, unselfishness, devotion to duty and the overpowering desire to render justice to all

regardless of race, creed, color or economic circumstances. It is certainly easier to modify systems, to replace democracy with authoritarianism, for example, but always the basic human elements involved remain the same. There may be a change of human objective, from the mere accumulation of wealth to a struggle for political power and position, but the evils involved in living the realistic life remain unaltered.

Efforts to transform man himself have failed because man is what he is. Education and environment can only bring out what he already possesses by heredity. They can not alter the basic pattern with which he is endowed. One environment may favor the appearance of certain characteristics, good or evil, but the others are there ready to come to the surface at the slightest opportunity. Perhaps some day the biologist, aided by the organic chemist, the biophysicist and the biochemist may learn how to control and modify the hereditary pattern or to alter the adult individual and in that way develop a new race of men capable of living the dream life. But until that day arrives, if it ever does, the world will go on more or less in the same way. History teaches us, much as we regret to accept it, that it can not be otherwise.

Is there no hope, then, for a better human society, where war and famine will be banished, where hate will be kept in abeyance and where human beings can live happily with reasonable security and with the knowledge that they can bring up their children with a reasonable approximation to equal opportunity? I firmly believe that such a human society is possible. The means of achieving it, though simple to record, are tremendously difficult to attain. For to achieve it, we must recognize and admit that human beings differ in their heredity and hence in their potentialities. Some will have to be the workers of the world, while others will be the leaders, the inventors, the more significant contributors. Each must be rewarded in accord with his significance and his contribution. There must not be, since there can not be, a dead-level society.

Another difference must also be recognized, namely, that some men are more just than others; some are more honest; some are more scrupulous; some are more tolerant and charitable and selfless. In short, we must recognize the fact that some men are capable of leading and directing the dream life better than others. If a community can voluntarily select such men as leaders—and it is difficult to visualize how a democracy like ours can do that—then human society will approach the ideal state as closely as it can ever hope to do. This does not mean that human society must be governed by visionaries, by men who lack force and personality. There are men who can live and plan and direct the dream life who also have force and personality. When we achieve this goal, we shall be putting our faith in men. The system will not matter. Their aim will be service to their fellow men without the evils that frequently go with power. But in order to keep such men in power, in order to make it possible for them to achieve and maintain the dream life, it will be necessary to implement them with adequate force capable of keeping the apostles of the realistic life in check.

Until that distant day arrives, if it ever does, we must go on wrestling with the same problems of organized human society, in greater or lesser degree, that have challenged thinking man down through the ages. Here and there, in isolated communities all over the world, circumstances will thrust benevolent and wise leaders into positions of power. And in these communities, the world will see the closest approximation to the attainment of the dream life for the brief period during which these unusual circumstances exist.

BEES RAISE QUESTIONS

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In many ways, the behavior of bees suggests our own ways. Old beekeepers always attribute to their pets the will, the motives, the emotions that they recognize in themselves. Bee-keepers speak of bees in the language of human conduct.

In comparing bees and men certain factors should be borne in mind. From the evolutionary standpoint, we are of course very distantly related to bees, but our common ancestry is not nearer than the segmented worms or perhaps the Cambrian Eurypterids which lived 100 or perhaps 1,000 million years ago. A common origin of our protoplasm explains perhaps the similarities between bees and men in their cruder chemical and physical structure, and even in the muscles, nerves, skin, digestive tracts and body fluids. Both man and bees are made up of proteins, fats and carbohydrates; our active tissues are all protein in nature; we store excess food in our bodies as fat (insects are very oily); we consume carbohydrates and oxidize them for release of energy. We all get our protein and carbohydrate from the plant world, and give it back to the plants during life, as water, carbon dioxide and nitrogenous wastes, and at death our bodies return to dust. There is little reason to think that our common ancestor was capable of experiencing any of the appetites or emotions that we know in ourselves, although Jennings does assert that if the amoeba could be seen and known as we see and know dogs, we should attribute to the lowest animal organism known to science "states of pleasure and pain, of hunger, of desire, and the like, on precisely the same basis as we attribute these things to the dog."

Man and the honey-bee are, however, so profoundly different in most respects that we might almost regard them as inhabitants of different planets. Where the two creatures resemble one another, we often seek some other explanation than that of common ancestry. Usually it is due to adjustment on the part of the bee to the same world as that in which we live and to which we are adjusted. For life is adjustment, and any serious lack of adjustment quickly leads to death.

Our common ancestor was without any means for breathing air or for motion on land or for resistance to the desiccating effect of dry air, or for terrestrial hearing or smelling or seeing. It follows therefore that the adjustments of men and bees to terrestrial life have been achieved quite independently of each other.

As to breathing, we draw air into our lungs, there load the blood with oxygen and then pump it throughout the body to carry oxygen to the tissues. The insect has a system of fine air tubes whereby the air itself is carried to every part of the body. For motion the bee has six limbs to our four, and surpasses us completely by the possession of four wings. But her limbs so closely resemble ours—made up of two long pieces and a set of small pieces at the foot—that we not only speak of the legs and the feet of the bee, but we call the parts femur, tibia and tarsus. Obviously this resemblance is strictly superficial. It is not due to common ancestry, but to the mechanical nature of the world we inhabit.

The skeleton of the bee consists entirely of her hard outer shell, which serves in place of bones. This shell also

serves to prevent desiccation. Our bones are inside us, and consequently we must have a special waterproof skin to keep us from drying up. The powerful muscles of the bee are attached to prongs and bars of the shell, which often project far into the insect's body. That this method is adequate is proven by the legs of the grasshopper and the wonderful flight of many higher insects. Once I saw a worker bee grasp a dead bee by her legs and fly up as high as the house and over a neighbor's lot before dropping her load. The muscles of the bee are "striped" exactly as are the voluntary muscles of the vertebrates. No worms have such muscles.

The eye of the bee is too complex to describe in detail, but it depends upon the lens-shaped bodies of dense refractive material which focus the rays of light. Of course, this is an adjustment to the nature of light-waves in relation to solid bodies. The food of the bee consists of nectar, or honey, and pollen, the latter being the richest bit of protein that plants produce. Why has man never found a way of eating pollen? I have tried it but without success; it didn't taste good. The nectar of flowers is mostly a very thin solution of cane sugar which the bee sucks up and swallows into a special pouch called the crop. The crop connects with the throat of the bee, as our lungs connect with our esophagus. In the crop or later, the cane sugar is partly inverted or predigested, becoming dextrose and levulose. This is exactly the effect of human digestion upon cane sugar.

In the hive, the bee regurgitates the thin solution of sugar which is received and placed in a cell of the honeycomb by a house servant. The water is evaporated by currents of air, set up by fanning by the wings of the bees. During this process the honey is tongued and tested by another class of workers. When a cell is full of sufficiently concentrated honey, it is capped over with wax and sealed. Now this honey, or nectar, serves as the carbohydrate ration for the bee, but pure cane sugar syrup does just as well. Consequently we may take away from the bees all the honey they make and feed them during the winter on a sugar syrup. At this point their digestions are very much like our own, but the inversion of cane sugar in both cases is due primarily to the nature of the sugar molecules, not to the relation between bees and men. Nor should it be assumed that all protoplasms can use the sugars interchangeably. Many bacteria can use but one or a few kinds of sugar and will absolutely starve if given only some other kinds.

Well-finished honey is about 20 per cent. water. A colony of bees will consume from 20 to 40 pounds of honey during the winter months when they can not leave their hives. For each pound of honey consumed, at least three quarters of a pound of water and one half a pound of carbon dioxide will be exhaled by the bees. That is, a hive of bees generates seven to ten quarts of water during the winter, all of which must be expelled from the hive. It is a delicate matter to get enough ventilation to eliminate the moisture, and yet not take in enough cold air to freeze the bees. Sometimes the water does condense on the inside walls and top of the hive. If it drips down and freezes at the entrance to the hive, completely stopping the entrance, the colony will quickly die for lack of air, asphyxiated by its own carbon dioxide.

The production of carbon dioxide by bees, as by other animals, increases with the temperature and the activity of the animals. When cold and at rest, bees produce but little carbon dioxide and need but little air. One cold evening in early winter, I moved two hives, disturbing the bees and setting them in motion. For some hours afterward it was neces-

sary for them to keep up a vigorous fanning with their wings at the entrance of the hive in order to expel the vitiated air and to draw in enough fresh, cool air. On moving one hundred hives of bees one autumn, we packed the entrances tight with soft snow in order to keep the bees from emerging. But the bees directed a current of warm air against the snow and melted holes through it in from three to five minutes.

In winter, or at any time of rest, the bees cluster together in a solid mass. Those at the center are constantly working out to the surface of the mass, while those at the surface are working in. A neighbor undertaking to kill a small colony by freezing, uncovered the hive, spread the combs apart, and left them overnight. The next morning, with the temperature at 10° F., all the bees were still alive. By remaining in a compact mass and continually exchanging places they were kept warm by their own body heat (combustion of sugars). The healthy cluster maintains a temperature of 57° or above.

Bees can not void their excrement except when flying; at least it is believed they do not. During the winter their abdomens become greatly distended with waste matter. If their stores are of inferior honey, this condition will be intensified and may prove fatal. If wintered out of doors, bees usually find days in January or February when they can fly out. Hence, wintering out of doors with sufficient protection is better than wintering in a cold cellar, for in the latter case so-called cleansing flights are impossible. Since bees can live all winter with only honey, *i.e.*, water and carbohydrate for food, during these periods they use protein sparingly in their life processes, and they must be in a state of extreme protein starvation when spring comes. There are in honey, usually, a few grains of pollen, and some pollen is commonly stored in the hive in the cells separate from the honey. Perhaps from these sources bees get a sufficient protein ration, but I think they eat only honey in winter.

The personnel of a colony of bees consists of three castes or classes: Drones, workers and queen.

Drones are male bees. They are much larger than the workers, and are present in a hive by tens or hundreds. The drones can not gather honey or pollen and can not even feed themselves, but are fed by the workers. They buzz very viciously but have no sting. Their sole contribution to a colony of bees is to mate with the queen, and since a queen mates but once in her life, very few drones ever mate. Drones are reared from June into summer. In September the workers drive them out from the hive and prevent their return. So they starve to death or die of cold.

Drones are the product of unfertilized eggs laid normally in the larger cells of the comb. All drones, therefore, are fatherless, though they have grandfathers and stepfathers, because queens and workers develop from fertilized eggs, and have a male parent. And a drone which mates with a queen will be the male parent of hundreds of workers and a dozen or more queens.

Beekeepers always think of drones as lazy, happy-go-lucky louts, with nothing to do but eat, sleep and buzz about on sunny days, waiting for an occasion for a mating. But for the drone, the mating is a serious matter, for the act is fatal. The queen returns to the hive with the end of the abdomen of the male torn off and hanging to her.

There are from 20,000 to 50,000 (some say 80,000) workers in a strong colony. The worker is an unsexed female, with only rudimentary ovaries, but in a queenless colony one or more of the workers may acquire the capacity to lay eggs. Probably this condition is brought about by the excessive feeding of selected

young bees. Such "laying workers" never leave the hive and never mate. Hence they never lay fertilized eggs; their eggs are fatherless and hatch out only drone bees or males. Such a colony soon dies out, since no new workers can be raised and the life of a busy worker in summer is only five or six weeks. Workers hatched late in autumn live over winter, and do a few weeks' work in spring. To get rid of laying workers, one has only to shake all the bees out of the hive in a grassy place, a hundred or more feet from the original position of the hive; the regular workers will easily find their way back to the old stand; the laying workers, never having been out of the hive, can not get back and will perish. Then the helpless, eggless colony will accept a new queen, if one is offered to it.

Workers alone have mouths for collecting nectar and the honey-carrying crop. They also have combs on their front legs especially suitable for combing pollen off their bodies. The second pair of legs has a notch through which the first legs can be pulled, to gather up the pollen; and the hindmost legs have each a little basket in which the pollen is placed and carried home. Workers differ greatly in their use of this natural equipment. Some return home all dusty with pollen, and let their sisters clean them up. Others enter as neat as a pin, with huge sacks of pollen on their legs.

Last summer a loaded worker entered an observation hive and presently walked along one side of the comb, then went over to the other side, rambled about over and through and under a cluster of bees, looking into various cells here and there and, finally, after several minutes, settled on a place to unload. She put her hinder legs deep into a cell, and remained for about a minute; then she pulled them out, leaving her two lumps of pollen loose in the cell. Immediately, another worker went in head first and remained for about a minute. When she came out, the pollen was tightly and smoothly packed in the bottom of the cell. The bee which lost the time in deciding on a place for depositing her pollen was typical, for most bees seem always to be just milling around aimlessly over the comb. Do not send the sluggard to the busy little bee to learn a lesson in efficiency.

Observers remark the same characteristic when the bees are building their marvelous comb. They run about without any semblance of order or continuity of work. A bee bites at the comb here, sticks on a bit of wax there, and runs on while others follow. But meanwhile the marvelous comb grows up before our eyes! The wax is secreted in scale-like pieces on the under side of the abdomen of the workers. To produce the wax they eat vast amounts of honey and hang in characteristic clusters over night. The wax appears in a few hours. Bees consume about twelve pounds of honey to make one pound of wax, but one pound of wax will build enough comb to contain sixteen pounds of honey. The cell of the comb is not only hexagonal—a response to the nature of the space in which we live—but its axis slopes upward, so the honey will not drip out. There is, therefore, a very definite right side up for honeycombs.

There are three sizes of honeycomb cells. Most of the cells are almost exactly one fifth inch in diameter. As long as the queen lays eggs in the cells as fast as they are ready, this size cell is made. If the workers get ahead of the queen, they build larger cells one fourth inch across. For storage of honey, even larger cells may be made. But all this variety is produced in an apparently disorderly, helter-skelter manner by a host of workers, running about over the comb. We have absolutely no conception of how a precise piece of work can be turned out in this way. Nor can we believe that

the method is economical or efficient. Apparently it succeeds merely by dumb persistence—by force of numbers and in defiance of time.

The workers are custodians of the hives; it is they who fly out and sting the intruder. But the different varieties of bees differ greatly in irritability. The gold-banded Italians sting only after rough handling, but a black bee will probably sting you if you simply stand within five feet of her doorway. This reaction is changed by puffing smoke into the hive or upon the bees. Certain it is that smoke induces the bees to rush to the combs and gorge themselves with honey without stopping to sting the intruder. After smoking the bees one can open the hive, lift out the combs one by one, and inspect them minutely. Sometimes not one bee will attempt to sting; at other times, however, a half dozen will leap on one's hand at once and sting with great energy. Why the calming influence of smoke?

Animals and plants respond to natural stimuli in a manner that has proven, in the last million years of experience, to be useful and profitable. A new and strange stimulus will call forth one or another of the reaction patterns that have been established by age-long experience. Is smoke a new experience, and the reaction fortuitous, or is it a very old stimulus with an adaptive reaction? Since bees have lived for ages in hollow trees, the smell of smoke may indicate to them that their tree is on fire and that the colony should move. So the bees load up with honey and get ready. It is probably possible so to smoke a hive that the workers will leave it, taking their queen along, but usually the queen simply hides among the bees or in some corner of the hive. This hiding of the queen is doubtless a reaction to the stimulus caused by opening the hive. In all the pre-human period bee hives have never been opened up and the combs removed except by predatory animals. And the combs were never put back in as I do it until the invention of the movable frame in 1852. Under such conditions the preservation of the colony depended upon the queen being hidden among the mass of the bees, or tucked away in some deep crevice. Then when the marauder had gone, she could come out and join the remnant of her family to reestablish a home in the same or another hole in the tree.

So when I smoke my bees, and proceed to tear open their hive, I turn loose two ancient behavior patterns—the behavior suited to a burning tree and that suited to an attacking animal. For the first, the bees fill up with honey and do not sting; for the second, they sting violently and hide their queen. The business of the beekeeper is to keep enough smoke in the air to hold the insects to the burnt-tree type of reaction. Even so, why the difference in irritability of the several varieties of bees?

The ability of bees to make long journeys—two to four miles—and return unerringly to their own hive is remarkable. The feat becomes more interesting when we see the bee yard containing 50 to 100 hives, all made as nearly alike as modern machinery and paint can make them, and packed so closely that there is just room for the beekeeper to pass between them. But interest culminates when we learn that this skill is the result of careful training. A young bee first emerging from the hive suns herself on the front porch. Later she flies out a foot or two and buzzes about facing the hive. Then she goes farther and farther, still facing the hive—say to ten or fifteen feet. Finally she makes a real collecting trip.

Last summer I placed a comb of bees in an observation hive, fastened them in, placed them in the cellar to cool off. They settled down at once. Twenty-four hours later I found they were humming

in a tone that indicates mild excitation. (One can tell what a bee is likely to do next by the tone of her humming, just about as well as you can predict the next act of a dog or a person by the tone of his voice.) I took my bees out to a new location and opened the little doorway. It was six P.M., just growing dusk. In a few minutes one bee found the open door. She crawled out, made sure of her freedom, and then stood by the door and buzzed till you couldn't see her wings. Soon another came, and she buzzed too. Then they all made for the door and poured out in a stream, mostly taking wing at once. For several minutes they made quite a swarm within 3 or 4 feet of the little hive, milling about in the air, all facing the hive. Then they spread out farther and farther, to 100 feet or more. I thought they must all be gone. But while I thought it, the crowd gathered again by the door, and all poured in as eagerly as they came out before. In a trice all were in and quiet. Had they been studying the location? Ordinarily, when collecting, they run out of the hive and take wing without a look behind; and returning, swoop out of mid-air directly into the doorway.

When it is necessary to move a colony, one should place a board or net in front of the hive in its new location, so the bees will be compelled to take notice as they come out. The obstruction can be removed after a day or two. There is no doubt that bees can learn to find a certain location, both for their home and for their collecting grounds. A good collecting ground is revisited until its resources are exhausted. Then a new place is sought and similarly worked. Ability to do this is essential to the life of the bee.

I do not see in this any general ability to learn. It is only an adaptation to the peculiar life of bees—gathering nectar from the successive fields of flowers from season to season—and the change of abode when swarming. It does not indicate any ability to learn in any other realm of knowledge.

When bees are much agitated by a disturbance in the hive or by the excitement of stealing made-up honey from whatever source ("robbing"), the bees do not usually settle down until nightfall; they have to sleep it off. The length of time for relaxation depends on the intensity of the stimulus. So it is with a person. When he is greatly excited, he gets a large dose of adrenalin poured into his blood from those little glands in his back. And he simply can not settle down until that disturbing hormone is oxidized or eliminated or sent back to its place. Ritter suggests that the human organization is unified by hormones. Does the bee have hormones? Does a puff of smoke let loose in her body fluids some guiding substances from some hidden gland? And when I open the hive, do I stir up some other hormone, which keeps Miss Bee literally on pins and needles until the hormone works itself out?

Speaking of robbing, whenever bees find a chance to gather real honey, ready made, they go for it and carry it away with the utmost haste and energy. They often tear a comb to pieces, a thing they never do in their own hives. They fight one another while gathering the loot. They are unusually irritable and liable to sting. Once about noon I left a lot of combs, wet with honey, exposed in my shed. On getting home at five o'clock, I found the air full of bees buzzing around the shed and the shed crowded with bees. A neighbor down the street called my attention to the great numbers of bees buzzing around his house, my bees stirred up by the experience of robbing. Were I a Maeterlinck, I could describe them as exhibiting all the passions of a madhouse or an army. With nightfall, the bees mostly came home. I put the exposed combs under cover by candle light, and next day all was quiet.

Bees sting in different ways at differ-

ent times. If one alights quietly on one's face or hand, she means no harm, and soon flies away. If she gets into one's hair by accident, she hurries down and stings. Why? because among the hairs she feels caught; the reaction is to injure and drive away the enemy. If she alights on one's arm and one's sleeve presses down on her, she stings. A drop of ammonia cures it. If her hive is disturbed she comes out with a shrill whistle of the wings, and the intruder is in for it. She alights on his glove, bends down her abdomen and gives a thrust. It misses its goal in the soft fuzz of the gloves. She thrusts again, with a violent contortion,—she misses. Again she thrusts, with a violence that nearly bends her double, and draws her abdomen into a sphere. One is obliged to think of it as an expression of baffled rage and savage bitterness. She looks and behaves like a veritable little fury.

The queen fulfils the Christian admonition that he who would be greatest must be servant to all. (That is the only Christian virtue about bees.) She has absolutely no freedom of action whatever. She can not feed herself, but is fed by her daughters. When she lays too many eggs, the workers withhold food and she lays fewer. If she lays too few, they feed her up. So do beekeepers. If that doesn't bring results or if she lays only unfertilized drone eggs, she is carried out and killed, and a new queen is raised. If she lays eggs in small wax cells, and she is young, she lays fertilized female eggs; if the cell is a large one, she lays unfertilized drone eggs. It seems to be simply a matter of the size of the cell. When the bees are moved to swarm out and leave the hive to start a new colony, the queen goes along with them. If she doesn't go, a guard of workers goes in and gets her. Two summers ago a swarm came out of one of my hives. I caught the queen with difficulty and awkwardness, put her in a cage after much fingering, and gave her and her flock a new hive. Next morning I found her lying dead in front of the hive, with a few bees crawling over her. Authorities tell me I handled her too much; she got a strange smell and the workers killed her.

When a hive is opened on a *rainy day* and rain falls into the hive, the workers are likely to kill the queen. These are reactions for which it is not easy to see an explanation. Once a colony was left queenless by such madness and without hope of ever getting a queen. Left to themselves they would have died out. But they were given the makings of a new queen, which they accepted, and raised a queen and produced 15 pounds of good honey.

Queens and workers come from exactly the same kind of eggs. Queens are raised in very large *cells,* as big as the end of one's little finger, and are fed as larvae upon very rich food called royal jelly. If one takes a young worker out of her cell and places her in a big cell with a bit of royal jelly, the bees will go and make a queen of her. Or, if the queen is removed, the bees will make several queens from the recently laid eggs. When, in 16 days, those new queens are hatching there are exciting times.

A queen emerges from her cell with a number of complete behavior patterns. One day a worker came by just as a queen emerged. She jumped on the worker and was about to give the death blow with her powerful sting when she suddenly stopped and got off. My informant remarked that "she discovered her mistake." Did she? Soon she met a newly hatched queen. Again she leaped on and this time she plunged her sting into the abdomen of her victim between the plates of armor, and the victim curled up and died.

After killing all her immediate rivals, the young queen lives quietly for a day or so, and then goes out on her mating flight. A few workers go with her. They fly up into the air and are gone

a few hours in the middle of the day. She meets the drone in flight and receives into a little sac enough sperm cells to supply her egg-laying for two, three, four or even five years—200,000 to 1,000,000 male sperms. She returns to the hive with a high degree of certainty. Whether she finds her own way back or is guided by her more experienced attendants we can not say. Having returned, she is groomed by her maids, and in two or three days more begins her career of egg-laying. *On occasion a vigorous young queen can lay 2,500 eggs a day, more than twice her own weight!*

For various reasons we often want to give a new queen to a colony—a queen of our own selection, which is quite possible if done correctly. First we must remove the present queen and be sure that no laying worker is at hand. It is well to wait three or four days until the bees have themselves built queen cells and begun to raise new queens. Then destroy all these beginnings, and the colony is hopelessly queenless. There are many ways of introducing new queens. Of course, the situation is absolutely new and strange in the experience of bees. They have no behavior pattern for such a situation. It can only call out some kind of behavior that has been developed for some other circumstances.

Sometimes in adding a new queen to a queenless colony this colony is joined with another. Now there are only two natural situations where a large number of bees enter a colony: First, where a swarm settles in a hole that is already occupied; in this case there is a strange queen as well as strange bees—hence some of the behavior towards strange queens. And, secondly, where the strangers come in to rob and carry off honey. In either case, the rightful owners do all in their power to drive off and kill the invaders. This, then, is the natural reaction when two colonies are united. Last summer I put a small group with a bigger one, and next day the ground in front of the hive was littered with dead bees. Apparently every stranger was killed. To obviate this difficulty, some beekeepers turn in a quart or two of strange bees into the hive and then sprinkle in a quart or so of water. The water changes the type of reaction. One old man tells me: "Oh, no trouble at all. If they get to fighting, just get a spoonful of flour and dust it into the hive all over the bees. Then they get so busy cleaning each other off that they forget all about their quarrel." Why does it work?

I have spoken of the bee as a combination of hereditary structures and behaviors. But it must be remembered that the parents of worker bees are drones and queens, and these parents do not have the characteristic structures nor the industrious or warlike habits of workers. How can workers inherit characteristics which their parents do not possess? Only, as some wag said, by inheriting from their maiden aunts.

While this inheritance has been considered a problem, it is really not so. Or, rather, it is a commonplace problem, and part of all considerations of heredity. Bees are improved by breeding from those queens whose offspring are most productive and least irritable. And nature too has certainly bred from those queens whose offspring best fitted themselves to their surroundings.

It is very easy for me to believe that the bee is a kind of automaton—a complex of physico-chemical reactions bound by and leading to a complex of behavior patterns—and that all is dependent on the nature of the materials and forces of our world and the million-year-old inherited experience of bees. But if that conception of the bee is true, what am I? If the bee could observe me as objectively as I observe her, would she not define man in exactly those same terms? Can she do otherwise? Can I do otherwise?

SCIENTIFIC PROGRESS AND THE EVOLUTION OF CAPITALISM

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Nature of Capitalism

It is necessary for the purpose of this paper on the evolution of the capitalist system in relation to scientific progress to attempt first a statement of the essential characteristics of capitalism, even though it would be difficult to obtain among economists a general acceptance of the characteristics as herewith given. Capitalism must be viewed not narrowly but broadly as an integral part of civilization. To understand the nature of capitalism it is necessary to consider not only its economic but also its non-economic characteristics, including the psychological, social and legal. From the economic viewpoint, capitalism is a system wherein the activities of production, consumption, distribution and exchange acquire certain distinctive characteristics. Under capitalism production is essentially large-scale in nature, and consequently seeks a widening market. Capital becomes of increasing importance as a factor in production, and labor is free to sell its services for a wage. Consumption is varied in nature, since income determines the needs of society, instead of the needs governing income, and the distribution of income among the members of society is such that a large proportion goes to a so-called middle class. The exchange system is conducted indirectly through the mediation of money and credit, and so capitalism operates under a price system with valuation having a definite pecuniary significance. Viewed from the standpoint of psychology, capitalism flourishes because of the profit motive in human beings who are driven to economic activity because of the urge to acquire greater income and wealth not for use but for the sake of having income and wealth. Capitalism possesses the social characteristic of a growing urban population. It also implies the legal concept which recognizes and protects the rights of private ownership of property. Under capitalism the technocological characteristic of labor-saving devices in the form of machines is well developed.

Certain political characteristics are also frequently considered as necessary features of capitalism. It is held that imperialism, in the sense of an aggressive over-seas expansion by political force, is an essential concomitant of capitalism. However, imperialism was present before the coming of capitalism, such as the expansion of the Athenian state, while imperialism was at a low ebb in the first half of the nineteenth century under capitalism. It is also maintained that liberalism is an essential institution of capitalism, but capitalism existed before the coming of liberalism, and moreover capitalism exists to-day in lands such as Italy where liberalism does not prevail. It is, therefore, best to limit the concept of capitalism to the characteristics given above. However, consideration will be given to the political habits which characterized the various stages of social evolution.

We will now seek to trace the evolution of the institutions which constitute capitalism with particular reference to the relation between them and scientific progress. It is assumed that social institutions pass successively through a rising stage, a developed stage and a declining stage which embraces the rising stage of

the new institution which is replacing the old. It is, however, essential to note that such evolution does not take place in any fixed or rhythmic cycle, and static periodization of social institutions must be avoided, for in the developed stage there may well come a point of crisis where an institution may either enter the stage of decline or may go forward to even further development. It is also necessary to recognize the fact that some institutions of capitalism did not begin with capitalism, but were present in pre-capitalist systems. However, these institutions became stronger and more prevalent under capitalism than under the previous systems. It is quite probable that post-capitalist systems may similarly possess institutions which exist now in limited form under capitalism.

Pre-capitalist Systems

In order to understand how capitalism evolved it is essential first to review briefly the preceding systems in the history of civilization. These earlier systems may be termed the collectional, the nomadic, the city-state and the feudal. In Europe the collectional stage covered the period from the dawn of history until about 12,000 B.C., and over these many centuries society, organized in family clans, lived by directly appropriating the gifts of nature. In the nomadic stage, society grouped into tribes, made some technological progress through sharpening its crude tools by grinding and polishing and also made economic advance through domesticating animals. In time the nomadic tribal system gave way to the city-state such as Sparta, Athens, Carthage and Rome, which were essentially political organizations formed to protect the lives and property of their own members and to exploit the lives and property of others. As a result, the city-states often engaged in total wars, such as the struggle between Carthage and Rome, which were fought for many years and for the objective of destroying the enemy completely. Society now made definite technological progress, since it not only improved its tools but also learned mechanical principles, such as the wheel and axle for chariots and oars and sails for seagoing ships. The pyramids of Egypt and the aqueducts of Rome are enduring evidence of the technological advance of the city-states. It is interesting to speculate why this technological knowledge of the ancient world did not result in the development of the machine and its extensive application to economic life. The factors which prevented such a development of the machine in the ancient world were probably the existence of slave labor which, because of its cheapness and its inefficiency, nullified the practical use of machines, and also the lack of an adequate supply of metal for tool-making.

Notwithstanding these limitations, the city-state possessed to a degree some of the essential psychological, legal and social institutions of capitalism. The desire for acquiring wealth was strong as evidenced in the denunciation of the business class and of the usurers by the writers of the Old Testament. Ownership of private property gradually became recognized in the early Greek and Roman laws until they were codified by Justinian. In time not only rights of private property but also liabilities under contract and under debt were defined. Moreover, the city-state included cities where large numbers were centered, but the total population still lived in rural communities.

Feudalism

The city-state attained its highest development in Rome, and through the strength of its military power and the soundness of its governmental system this civilization flourished for several centuries. In the course of time even this powerful organization declined and was

replaced by feudalism which lasted for about a thousand years. Feudalism was essentially a military and legal system which sought to protect life and property after the collapse of the Roman Empire. In its early stage, from about 400 to 1000 A.D., one dreary century followed another with society falling to ever lower levels of human misery, and the flickering light of civilization was kept alive only in the monasteries. The one social achievement of the period was the contribution of early Christian thought in opposing slavery and preaching the principle of free labor. However, a large part of the population continued in serfdom.

The developed stage of feudalism, approximately from 1000 to 1400, witnessed social progress. The technological advance of this period is evidenced by the medieval cathedrals and guild halls which still remain. Western Europe now attained political, ecclesiastical and linguistic unity. For the first time since the fall of Rome a large part of Europe was brought under a single political control through the Holy Roman Empire. Also important was the unity of faith and the coordinated religious civilization of the Res Publica Christiana. This vast domain of the state and church was bound together by the use of the common language of Latin. Local economic coordination was accomplished in the rural communities through the manorial system and in the towns through the guilds. The inhabitants of the towns acquired the status of free citizens, but on the manors serfdom largely prevailed, and labor was generally not free to choose its occupation.

The economic policies of both the church and of the guild system aimed to restrain the growth of capitalist institutions. The church sought to check the profit motive by the theory of the just price and by the condemnation of usury. Thus consumers were to be protected from the avarice of producers, and borrowers safeguarded from the depredation of lenders. The guilds endeavored to stifle competition, prevent unequal accumulation of capital by one member as against another and enforce a standard living wage for all. Thus under feudalism, through authoritarian regulation, production operated in a local market essentially for use, to provide the individual member with the necessities for meeting his immediate needs, and expenditures for these needs were determined by the income of the individual. Unity and stability were the underlying aims of the system.

Rise of Capitalism

Leading students of capitalism are not in agreement as to the exact time of the rise of capitalism. Tawney places it in the eleventh century, and Sombart in the twelfth century. It is difficult to fix the time for the beginning of capitalism, but for this study it is sufficient to note that capitalism rose as feudalism reached its apogee after the thirteenth century.

From the fourteenth to the eighteenth century Western Europe experienced drastic institutional changes in its political and religious habits. In general unity gave way to variety and stability to flux. First the Holy Roman Empire yielded to national sovereignties. The growth of these national states had a beneficial and an adverse effect. On the one hand, it led to the more effective protection of private property rights within the new national borders and gave the necessary legal encouragement to the accumulation of capital. On the other hand, the growth of nationalism led to overseas expansion and to bitter international wars, particularly throughout the eighteenth century when the great colonial powers clashed in the valleys of the St. Lawrence and of the Ganges.

The second important institutional change was the replacement of Catholicism by numerous Protestant sects over

a large part of Western Europe. Society, no longer tolerant of the economic rules of the Church, turned to materialistic concepts of life; the individual no longer toiled merely to provide for his limited immediate needs, but, impelled by the new capitalistic spirit, worked to satisfy demand unlimited in scope.

For a number of years social scientists have been engaged in an acrimonious controversy as to whether the capitalistic spirit was the fundamental cause of the rise of Protestantism. It has been argued that Protestantism, and particularly Calvinism, recognized usury and other economic practices banned by the Catholic church, and that religion was thus employed to further the ends of the rising capitalism. However, as shown before, the acquisitive spirit existed even in the Ancient World, and it is probably nearer to the truth to say that Protestantism, as part of the Renaissance movement toward realism, encouraged thrift and hard work, thereby bringing about a changing attitude toward life and thus stimulated the growth of the capitalist spirit. Unquestionably the new social attitude introduced by the Reformation contributed to the decline of feudalism and the rise of capitalism.

Old Capitalism

The fifteenth and sixteenth centuries witnessed marked technological progress which deeply influenced all phases of European civilization. The discovery of the magnetic compass and the improvement of shipbuilding enabled Europeans to cross oceans, and the age of discovery followed: the printing press made possible the dissemination of the ideas of the Renaissance. New mining methods enabled the profitable exploitation of the mineral resources of Europe; and in southern Germany mining operations were conducted on a large scale, even in the form of what may be described as cartels. Technology affected not only the arts of peace, but also of war, for gunpowder smashed the last strongholds of political feudalism. The machine was extensively used in military operations, and war now required the services of the engineer as exemplified by Vauban.

The furnishing of capital and credit for all these operations made necessary the development of a financial system, including bankers, such as the Medici and the Fugger families, and exchanges for transactions in goods and moneys. As early as the twelfth century securities were used in financing business transactions, but such cases were very rare until the nineteenth century.

This period of incipient capitalism witnessed a rapid accumulation of capital. The influx of precious metals from South America, the extensive commerce in raw materials, foodstuffs and ornaments and the mining operations in Europe brought enormous profits. Not only did capital increase in amount, but it also changed in form and in social ownership. Under the feudal system capital was mainly fixed in the form of land, whereas under capitalism a large proportion was in liquid form such as raw materials and cash. To a large extent the social ownership of capital shifted from the landed aristocracy to the merchant and to some extent to the banking class. In many cases the wealthy merchant and banking families married into the old nobility to create a new aristocracy. For the greater part the new economic groups formed an ever-growing middle class of its own which for the first time became an important factor in the social order. Another important social movement was the growth of large cities such as Naples, Paris and particularly London.

Thus by the end of the eighteenth century the system prevailing in Western Europe had acquired the character-

istics of capitalism, as explained at the start. There were now the beginnings of production on a large scale, an expanding market, no longer local but now national in scope, the increasing importance of capital, a laboring class free to choose its own occupation, a varied consumption, a widening distribution of income with the rise of a middle class, a monetary and credit system, a strong profit impulse unfettered by the restraints of the church, the growing use of machines, the recognition of private property and the growing urbanization of population.

Rise of the New Capitalism

The end of the eighteenth and the beginning of the nineteenth centuries marked the passing of what may be considered the old capitalism and the coming of new capitalism. Over these years Western Europe, particularly England, experienced a rapid advance in technical knowledge, invention and physical science, generally described as the industrial revolution. To early commentators it seemed a new and sudden movement. However, as noted before, technological advance was moving forward for several centuries and so the industrial revolution was neither new nor sudden. The movement was, however, distinctive in that science, which had hitherto been the concern of a few intellectuals, now absorbed the interest of many hard-headed business men, who, as a result, hit upon important inventions and discoveries in textiles, transportation and other economic fields.

One of the distinctive institutions of the new capitalism was liberalism. It was essentially a revolt against the restraints of both the church and the state, and developed an intellectual attitude favoring individual freedom which exerted a profound effect upon society. Liberalism had definite political, economic and technological results. It led to the secularization of the state and the exclusion of the church from temporal affairs. Liberalism brought about the growth of democracy, the widening of suffrage and the development of representative government in the conduct of national and local affairs. In the economic field, the doctrines of liberalism were spread by the great classicists who preached individual initiative and laissez-faire, and urged the removal of the restrictions of the state from both domestic and international business operations. At home business was to be conducted on the basis of free competition, and abroad there was to be a world economy operated under free trade and the international division of labor. Science, essentially dynamic in nature, flourished under the freedom offered by the political and economic principles of liberalism.

Another potent institution of the new capitalism was the pacific nature of international relations in the nineteenth century. The Napoleonic Wars may be regarded as a continuation of the intense international rivalry of the old capitalism. The period from the banishment of Napoleon to St. Helena to the outbreak of the World War was comparatively peaceful in nature. True, these years were marked by several wars, but they were local in nature, usually short in duration, fought for limited objectives and their effects were not serious. Even the fires of imperialism abated after the virtual destruction of the Spanish and French colonial empires and after the loss of the Thirteen Colonies to Great Britain.

A third characteristic of new capitalism was the internationalization of the market. Under the old capitalism the market had expanded from a local to a national area, but under the new capitalism the market became thoroughly international in scope. The growing output of the factories was sold not only at home but also abroad. In addition there

was also the export of a growing volume of capital from such countries as England, Holland and Belgium.

A fourth important development under the new capitalism was the creation of a financial mechanism for mobilizing capital through the use of stocks and bonds. Under the domestic system of the old capitalism the worker supplied the fixed capital in the form of tools and workrooms, while the entrepreneur furnished the working capital to pay for wages and raw materials. This structure of capitalism was entirely changed by the technological improvements of the nineteenth century, for under the factory system of the new capitalism the entrepreneur contributed not only working capital but also fixed capital in the form of factories and machines.

In the past business was largely organized in the form of single ownership or partnership, and capital came from the entrepreneur or his associates. In the nineteenth century under the French Commercial Code and the British Companies Act, the corporation acquired limited liability and formation under a general rather than a special act, and as a result became the dominant form of business organization. Capital was now provided largely by the investor who purchased the securities of corporations and of governments.

Developed Stage of the New Capitalism

Throughout the nineteenth century the new capitalism moved from its early to its developed stage. This evolution took place at different times in the leading countries of the Western World. By the middle of the nineteenth century the old order in England, Holland and Belgium gave place to the new; by the end of the second quarter of the century France and the United States experienced the ascendancy of the new capitalism, and in the last quarter Germany, Switzerland and the Scandinavian countries attained this stage. The rest of Europe, as well as Asia and South America, continued in various stages of social evolution, and in some cases institutions of feudalism survived along with those of the old capitalism and of the rising new capitalism.

In the developed stage of the new capitalism technological advance was no longer left to the chance of the business man in his workshop but was largely the result of the systematic research of the scientist in his laboratory, particularly in the field of electricity and chemistry.

In the developed stage the distinctive institutions of the new capitalism grew stronger. Political liberalism made rapid progress with the creation of constitutional monarchies and of republics. The market became more and more internationalized in nature as the area of the enforcement of contracts widened, as currencies were placed on a gold basis and as uniform commercial codes were adopted. As a result the international flow of goods and of capital was encouraged. The financial mechanism for mobilizing capital through the flotations of stocks and bonds was perfected with the formation of powerful incorporated banks replacing the old private bankers and the operations of stock exchanges in the metropolises of Europe and the United States.

Under the new capitalism population experienced its most rapid increase in all history, for from 1820 to the outbreak of the Great War the number of persons in the world doubled. A large part of this increasing population was sustained at an ever higher standard of living, for income and wealth rose sharply and were widely distributed. In the latter half of the nineteenth century the standard of living of society as a whole was higher than in any other period of history, for the world was producing more coal, more iron, more cotton and more wheat, and at

the same time the consuming power of Western Europe and the United States was highly satisfactory. Unquestionably the developed stage of the new capitalism represented the highest level of social progress in all the history of civilization. These conditions refuted the gloomy Marxian forebodings of crises of increasing severity and of deepening social misery, resulting in the disappearance of the middle class and eventual revolution. The error of Marx lay in the fact that he mistook the passing of the old capitalism for the passing of capitalism as a whole, and although he recognized some of the characteristics of the new capitalism, he underestimated its strength.

In certain respects in both its early and developed stages the characteristics of the new capitalism were the same in nature as those of the old capitalism but only more pronounced. The technological advances of the industrial revolution, although on a greater scale than before, merely continued the progress of the previous centuries. Similarly, the economic characteristics were about the same as before but only more intensified. Production had been expanding throughout the seventeenth and eighteenth centuries, but the sweeping technological improvements tended to increase production more rapidly. Consumption for several centuries had become more varied, but as factories turned out their increasing production, the consumptive habits of the peoples of Western Europe became much more diversified. As the factories drew workers from the farms, the trend toward urbanization, in progress for several centuries, became more rapid.

However, it is clear that the new capitalism acquired definite characteristics of its own. The philosophy of liberalism completely changed the political nature of European civilization and replaced autocratic governments with limited monarchies and republics. Moreover, the international struggles of the eighteenth century were followed by a period of relative peace. Manufactured goods were produced not only for home consumption but for export, and the market now became international in character, for goods and capital flowed freely among nations. The mechanism for mobilizing capital and credit changed, since private enterprise organized as corporations and also governments obtained their funds largely through the flotation of securities. The distinctive characteristics of nineteenth century capitalism in its early and developed stages were, therefore, its liberalism, its pacific nature, its international economic market and its mechanism for mobilizing capital by the use of securities. The civilization of Western Europe in the nineteenth century may therefore well be described as a liberal, pacific, international security capitalism.

Crisis of the New Capitalism

Even before the outbreak of the World War, these distinguishing institutions of the new capitalism were beginning to lose their strength. While the political doctrines of liberalism continued to spread, its economic principles were being checked. There was an increasing extension of governmental regulation of national and international business activities not only in countries such as Germany, which never really accepted the doctrines of economic liberalism, but even in England and in the United States. Moreover, the era of international peace was passing, for the imperialism of the old capitalism revived and the leading nations of Europe once more brought large overseas territories under their jurisdiction. The last decade of the nineteenth century witnessed the beginning of the armament race, which was to culminate in the catastrophe of August, 1914.

In the post-war period there were definite changes in the distinctive institutions of the new capitalism, with partic-

ular reference to liberalism, international political relations, international markets and the security mechanism. The post-war period experienced a decline of liberalism and a rise of fascism. In the leading liberal nations, constitutional government was seriously weakened, and in other countries political power was usurped by communism and fascism. Fascism is to-day exerting as determining a force on the capitalism of the twentieth century as did liberalism on the capitalism of the nineteenth century. In authoritarian philosophy fascism is regarded as the inevitable outcome of the declining stage of a matured capitalism. As a matter of fact, fascism has made its greatest progress not in countries where the new capitalism attained its highest development but in those countries where its appearance came late. Germany was the last of the great capitalist countries to enter the stage of the new capitalism, while in Italy it made slow progress before the war and in Japan the system has not even outgrown some of its feudal characteristics. Fascism in these countries has rather been the result of the collapse of an immature new capitalism with insufficient strength to bear the war and post-war burdens which only a developed new capitalism could support. Fascism, with its repudiation of liberalism, its militarization of society, its desire for economic self-sufficiency and its effort to abolish the private security mechanism, is diametrically opposed to the distinctive features of the new capitalism. In fact, fascism with its emphasis upon authority, stability and unity, its limitation on the profit motive, its impairment of the concept of private property rights, is in part a reversion to feudalism.

The international political relations of the twentieth century also constitute a drastic change from those prevailing under nineteenth century capitalism. Not only was the period of comparative peace followed by war, but the character of war reverted to the nature of pre-capitalist conflicts in the sense of total wars for the purpose of crushing the enemy completely and keeping him subjugated irrevocably under a Carthaginian peace. Modern war, perfected by the application of science, is to-day not only disastrous for the vanquished but also for the victor, since the new capitalism mobilizes all nations so efficiently that victory is followed by the complete exhaustion of material and spiritual resources. Imperialism also has changed in nature, for while in the nineteenth century the great powers expanded their colonial empires by acquiring the territories of weak states, in the twentieth century, since there are no longer new colonial areas, the powers seek to wrest overseas possessions from each other.

Another serious impairment of the distinctive features of nineteenth century capitalism has been the narrowing of the international market. The flow of goods and capital among nations has been seriously impeded by restrictive measures such as mounting tariff barriers, embargoes and currency regulations. Not only have the fascist nations checked the international movement of goods and capital, but even liberal countries have followed restrictive policies. Regulations for the protection of private property in foreign countries have been swept away, the actual confiscation of property during the war and the virtual confiscation during the depression have struck serious blows at the international markets of the new capitalism. As a result world trade has declined and the export of capital has virtually ceased.

The security mechanism of modern capitalism has also been shaken to its very foundations. In almost every country the increasing instability of security prices has brought heavy reverses to banks which have been seriously weakened so

that government support has been necessary, private capital markets have almost ceased to function and the stock exchange operations are near a standstill. Demand for capital comes mainly from the national governments which float securities largely for armament expenditure and unemployment relief. As a result of public debts created mainly for unproductive purposes supported by a dwindling proportion of wealth, and interest payments covered by a declining amount of national income, the quality of public credit has depreciated.

Conclusion

From this paper, which has sought to review the evolution of the institutions of capitalism, it is clear that these institutions, being dynamic in nature, are ever changing and are ever giving way to others. The tempo of this change is now more rapid than in the past, and so the replacement of older institutions with new is at a much quicker pace. We are in the current of an ebb tide drawing society from the system of the nineteenth century capitalism which, as a result of scientific advance, gave the world the highest level of material welfare in the history of civilization. The essential institutions of this system, namely liberalism, international peace, an international market and a private security mechanism, are declining, and in some cases are even being replaced by pre-capitalist institutions.

What are the problems of the relation of science to these changing institutions of our present-day capitalism? First, can science, which flourished under nineteenth century liberalism, continue to progress in an atmosphere of quasi-liberalism or fascism or communism, and can the spirit of inquiry explore the still unchartered fields of science in an environment which stifles the free expression of the individual? Can science continue to improve the art of war without itself being destroyed? Can society reap the benefits of scientific advance in the form of a high standard of living and high national income in a self-sufficient national economy? Can capital and credit to finance scientific advance be obtained if the private security mechanism does not function? These are the problems which confront the physical and social scientists, and these are questions which press for an answer.

A QUANDARY FOR SCIENTISTS

Much of the world is at war. We are fortunately able to stand aside, but no evaluation of the condition and program of an institution can be completely divorced from the stress of the times in which it operates. Even in these fortunate United States all plans are thus conditioned, and every individual is thus affected.

The scientist in particular is faced with a quandary. The same science which saves life and renders it rich and full, also destroys it and renders it horrible. Is it then possible to remain in a detached atmosphere, to cultivate the slowly growing body of pure scientific knowledge, and to labor apart from the intense struggle in which the direct application of science now implies so much for good or ill? As with an individual, so with a scientific institution; we can not consider the immediate future of the Carnegie Institution without taking cognizance of the conflict of emotions which is inevitably present.

The quandary may be immediate and direct. Science and its applications have produced the aircraft and the bomb. Entirely apart from all questions of national sympathies, from all opinion concerning political ideologies, we fear to witness the destruction of the treasures of civilization and the agony of peoples, by reason of this new weapon. As science has produced a weapon, so also can it produce in time a defense against it. Science is dedicated to the advance of knowledge for the benefit of man. Here is a sphere where the benefit might perhaps indeed be immediate, real and satisfying. Can a scientist, skilled in a field such that his efforts might readily be directed to the attainment of applications which would afford protection to his fellow men against such an overwhelming peril, now justify expending his effort for any other and more remote cause?—*Report of the President of the Carnegie Institution of Washington, 1939.*

THE PREDICTION AND CONTROL OF ACCIDENTS

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UNTIL quite recently it was customary among many engineers and many psychologists, as well as among the lay public, to look upon industrial and traffic accidents as primarily due to chance factors which could not be brought under control. More recently there has been a marked tendency to ascribe many accidents to personal behavior in the individuals concerned; that is, to variations from a standard pattern of right and safe behavior. The remedy obviously lay in training, since the deviations were assumed to be matters of habit that were largely under voluntary control.

The effectiveness of the extensive and intensive safety training programs has often been startling. In some instances they seem to have almost reached the limits of effectiveness, considering the time and effort devoted to them, but accidents continue, withal at a lower rate. The means of control have not, however, been exhausted.

Investigations by Greenwood and Woods in 1919, followed by that of Newbold in 1926 covering 16,000 British cases, and further supported by the findings of Bingham and others in the United States, point to one conclusion: There are some individuals who are, by reason of certain inherent characteristics, predisposed to have accidents. It was upon such a conclusion that the experimental investigations of Farmer and Chambers were predicated.

These latter investigations, made under the auspices of the British Industrial Fatigue Research Board and published in its series of bulletins, demonstrated conclusively the possibility of further reduction of accidents through the identification of individuals having the accident-proneness characteristics. Their results indicated that the selection of industrial workers by tests would effect a 50 per cent. reduction of accidents, since it has been well demonstrated that the most able workers are also the safest and that work done correctly is done safely.

The British investigators found no relationship between intelligence, as usually measured, and the accident records. They did find, however, that three tests of the considerable battery used showed substantial relationships with the records. These three tests were choice reaction time, dotting and the pursuit meter, all well known to psychologists.

It is important to note that each of the three tests involves the use of attention and perception in conjunction with muscular movements in its performance. Since it was quite impossible to separate the perceptual factor from the motor control factor, the two entered into the final scores in unknown amounts. The effect of this was to reduce the amount of actual relationship that was present in the data.

A smaller investigation made some years ago by this writer indicated that only moderate relationships between accident records and tests were obtainable when scores were handled in the conventional method used by the British investigators. Far more significant relationships were found when the *differences between scores* on perceptual and motor tests were compared with an index that took account of both frequency and severity of accidents.

The foregoing results lead to the hy-

pothesis that accident-proneness is a phenomenon associated with discrepancies in level between perception and motor reaction. It was observed that persons whose perceptual level is equal to or higher than their motor level are relatively safe, while those whose perceptual level is lower than their motor level are accident-prone, with records of more frequent and more severe accidents than the former group. This implies that those who can see faster than they can react are relatively safe, while those who react faster than they can see are accident-prone.

It does not follow, however, that all uncorrected defects of vision contribute directly to slow perceptions and thus to accident-proneness. It is apparently possible to have a variety of such defects and still get perceptual cues that are quite adequate for effective and safe behavior. While defective vision tends to reduce the speed of perception, this latter may not be reduced below the level of the motor reactions and thus make the person accident-prone.

There is some evidence to indicate that certain individuals suffer an early and rapid breakdown of the speed of perception under the influence of fatigue, alcohol and distraction. In others the breakdown seems first to affect the speed of motor reactions, leaving the speed of perception relatively unimpaired. This latter group would tend to be relatively safe under these influences as long as the perceptual level is not reduced. On this hypothesis, however, the introspective evidence of the individual himself should not be sufficient to justify his working at a dangerous task while excessively fatigued or driving his automobile while intoxicated. The foregoing evidence does raise some doubt as to the validity of measures of vision and of the alcoholic content of the blood as bases for a judgment of impaired skill and safety. The effect of these latter on perception seems to be the real criterion.

In order to make such comparisons of levels it is necessary to reduce the scores on the tests to some common scale by one of the usual statistical methods. It is necessary also, in any further and more exact measurement, to design tests that will give measures of the function intended that are as free as possible from other complicating factors. That is, a measure of visual perception should be as nearly free from the motor factor as it is possible to devise it. A motor measure should be practically free from the perceptual factor. While the correlation with each other of the tests used by the writer was only .30, this figure indicates an amount of overlapping that can be still further reduced.

It is significant that in the writer's investigation two relatively safe groups of industrial workers were found—the very good piece-workers on assembly operations and the very slow group of day-rate workers. It would seem that the latter avoided accidents by a slow rate of work. This is shown in Table 1.

TABLE 1

Foreman's ranks (earnings)	Sum of index figures, by eighths	Sum of index figures, by quarters
1–5	2.24	4.83
6–10	2.59	
11–15	2.01	7.28
16–20	5.27	
21–25	4.49	13.35
26–30	8.86	
31–35	1.88	7.27
36–40	5.39	

The preponderance of accidents in the third quarter of the group—the quarter containing the workers who were barely making the piece rates—is striking. If tests had been used in employment selection, most of the persons in these two lower quarters would not have been employed. This alone would have effected a reduction of accidents amounting to 55 per cent., a result that compares favorably with the estimate made by Farmer and Chambers. If the difference-scores had also been used for selection, the reduction would have been much greater.

Table 2 shows, for the same group, the marked tendency of the difference-scores to pick out the individuals with the high frequencies and severities:

TABLE 2

Difference scores (perception minus motor)	Sums of accident index by Eighths	Quarters	Halves
+60 to +29	.71	4.29	7.71
+23 to +18	3.58		
+15 to + 8	.57	3.42	
+ 6 to − 5	2.85		
− 6 to −11	2.88	6.57	25.04
−12 to −15	3.69		
−15 to −21	9.00	18.47	
−21 to −48	9.47		

If employee selection were made using both methods of test score application, a reduction in the average accident index of as much as 75 per cent. might be achieved, and this quite independently of other safety education and training measures. In fact, in one group of new employees thus selected, the actual reduction was 70 per cent., in comparison with the records of a group selected by the usual interview technique.

A still further reduction in accidents might be achieved by classifying jobs and work areas in terms of the hazard they present and assigning to the most dangerous work the applicants least likely to have accidents, and to the least dangerous work the applicants most likely to have accidents. By this method a given set of workers could be distributed so as to effect a substantial reduction in accident rate and severity.

What are the prospects for attacking this apparently inherent accident-proneness in some persons by education and training? It must be confessed that the results of the attempts to modify the test scores by training have been discouraging. The tests seem to be measuring innate qualities that can be modified only slightly and that with great difficulty, perhaps only temporarily.

The better approach to control seems to be to discover the degree of proneness of a person and then to place him in an environment in such a way that he will not be subjected to hazards beyond his tested limitations. Knowing his limitations, he may, by the exercise of judgment, avoid situations that would result disastrously. If the hypothesis is correct, and if the measurements represent a new area of stable individual differences, the airplane pilot, the automobile driver and the dish-breaking domestic servant are as suitable subjects for testing as is the industrial worker. One of the interesting characteristics of the proposal is that since the measurements can be made before selection and before training is undertaken, many severe and some fatal accidents may be avoided.

ON SCHOLARLY WRITING AND CRITICAL REVIEWING

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The Scholar

A SCHOLAR is one who loves learning for its own sake and will peruse the record because he reveres it. He will never imitate those who write as if nothing had ever before been disclosed in their fields of inquiry. Certainly he will not agree with those who frankly say they are interested only in their own research and do not care what others may have done. He will realize that a well-rounded review is much more useful than scraps of new, or supposedly new, information. Failure to summarize previous work is lamentable not only as indicating ignorance or lack of appreciation of pioneer endeavor, but is furthermore actual treason to scholarship because it handicaps the education of later students. Giving due attention to previous work is by no means detached altruism, for it may result in many a suggestion or ripen many an inspiration bearing on the scientist's own studies. Knowing what has been done is especially useful in forestalling futile repetition of argument or research and in preventing foolish claims of originality. In a word, acquaintance with one's subject, the more complete the better, is advisable for the strictly practical reasons of avoiding mistakes and evading criticisms.

The aphorism that "Art is long and life is short," doubtless inspired in Hippocrates by the study of medicine, applies as well to most research. The difficulty of accumulating adequate material, the need of painstaking study and reflection to get the most out of it, the requirement that every profitable method of approach be utilized, both in the field and in the laboratory, and the necessity of collating pertinent knowledge from every related field so that findings may be properly interpreted—the overcoming of these difficulties and the satisfying of these needs are not the work of a moment. The scholar must, therefore, have patience and an underlying persistence in pursuit of the truth that is something far deeper and better than the more lauded, but often superficial and unproductive, trait called enthusiasm.

The scientist, the scholar searches for truth but accepts the fact that his findings are only approximations to the truth. He strives ever for verification of previous, and for accumulation of new, knowledge so that there may be better and better approximations to truth. He is therefore tentative in expression and humble, not dogmatic, in attitude. He does not perform research to get support for a belief or policy; he does not anticipate or predict the results of research; he awaits them. Because he has no fixed expectations, he is not disappointed by the way the finger of truth turns. What appears to be truth suffices for him and is accepted for what it seems to be worth until something better can be developed. Indeed, as he must have reverence for the past, must be industrious in his calling, exhibit not only persistence but patience and moderation and abide always by the truth so far as it is possible to know the truth, the scientist must exemplify in his own person about all the qualities implied in the phrase "a gentleman and a scholar."

Scholarly Writing

To be scholarly in writing means to manifest learning. Good composition

granted, scholarly writing is that clearly showing mastery of its subject. This requisite prevails in both current and historical senses. The scholar must know not only his own research but that of other students in the same and related fields. Without knowledge of the foundation and progress of one's subject, it is impossible to be scholarly. The scholarly attitude implies devotion that tolerates no slackness of effort and reverence that appreciates the accomplishments of predecessors.

Scholarship seems difficult, yes, *is* difficult. It should be the goal of all scientists, yet when pursued too far, it becomes a quest for a perfection that is unattainable. Those who insist on completeness of knowledge and final accuracy in every detail will never finish their work. For production, there must be a compromise, say at a point where, under the circumstances, one has done the best one could. The compromise writing should, however, be as scholarly as practicable—a consummation that should be aided by editors, and held up as an ideal by critics—reviewers who though often disparaged are, at their best, essential to the building and maintenance of high standards of composition and worth.

Tasks for the Editor

In view of these praises of scholarship and scholarly writing, it is certain that editors will feel that most of their experience with these commodities has been in their tentative or formative stages. Scholars there must be or there would be no meaning in the word. Most of the scientific writing that comes through editorial channels, however, is not contributed by finished scholars. As in all lines of endeavor, it is the lower ranks that are most crowded. Neophytes do the bulk of the writing and they need the help of editors far more than they receive it.

Institutional editing, in general, is well organized and efficient, giving a good degree of dignity, accuracy, and clarity to its products. The less formal and mostly unpaid editing of scientific periodicals, however, is often not attended with such favorable results. In a good many instances, apparently, no real editing is done. A few commas may be added or tables and bibliographies made to conform to the adopted style, but on the whole, manuscripts are merely accepted or rejected. This practice evades editorial responsibility and is unfair in that a well-written paper may be accepted, though deficient in accuracy, while a "diamond in the rough" so far as substance is concerned, may be rejected. To contribute to the advance of knowledge, it is just the authors of these promising but poorly expressed articles who should be helped. Editorial efforts spent in aiding these writers with references, supplementary information, and suggestions as to better expression will in most cases be appreciated and, in the long run, will be repaid a thousandfold in terms of improved scholarship.

Writers not always being as scholarly as could be desired, editors should improve their product, certainly not print it just as received. One must wonder why an editor recently permitted an author to state that a certain wild duck is wholly a vegetable feeder when reference to an easily available compendium would have revealed that the statement is inaccurate. Why did another editor pass the statement that a specified invertebrate has no parasites and no enemies, when probably not a single organism in the world enjoys such advantages, and in the same magazine a few years previously there had been an article devoted to the bird enemies of this very creature?

Again we read in an ornithological periodical an assertion that the finding of some badly mutilated bird bodies washed ashore at a certain place extended the range of the species some 400 miles. Such records prove nothing as to the range of birds, as was pointed out in the same journal nearly twenty years be-

fore by its very capable editor of that period.

Why do such slips continue to occur? The main reason, seemingly, is that the prime canon of scholarship—knowing what has gone before—is not observed either by authors or editors. To many, abstracting media, summaries of literature, bibliographies, and indexes apparently mean nothing. There are "none so blind as those that will not see."

Critical Reviewing

It is not pleasant to be a critic, at least not permanently so, for there are repercussions. Hence critics, active in their youth and prime, usually mellow with age. Literary authors stung by criticisms have condemned critics as men who have failed in literature. But in American science this is distinctly not true; three of the leading ornithological critics, for instance, were Allen, Coues, and Merriam—all outstanding writers.

Like a leader of the flock in the theological field, the critic apparently is one who is "called." What calls him usually is inaccuracy, disregard of background, or reckless speculation that clashes so severely with the standards he prizes that he can not remain silent. In other words, it is departure from scholarliness, perpetrated by authors and permitted by editors, that arouses the critic so that he feels he must speak.

If unreliable writing is allowed to pass unchallenged, many in these days of specialization, when practically every scientist outside of his specialty is a layman, will perforce be deceived. In view of that situation and of the ever-increasing flow of publication, the need for critical reviewing is greater than ever before. Yet the practice is manifestly decadent.

Formerly, under the system of rugged individualism, the critic was encouraged; now under the brotherhood-of-man philosophy, he is discouraged. The proletariat of science distrusts one who still adheres to principles and puts accuracy above expediency.

To an old-fashioned critic, it appears nowadays that no matter how trivial the topic nor how ill-judged the content of an article, if it be presented in "constructive" form as an alleged contribution to knowledge, it is accepted for printing. On the other hand, a review calling attention to crudity, incompleteness, or illogicality of a published paper is rejected as being "destructive."

Limitation of discussion is not in accord with the spirit of science, in which all questions should be forever open. Suppression is alien to science and should be also to publishing media and institutions dealing with any phase of science. Suppression is a trait of authoritarianism which the proletarians usually get for their pains instead of their vaunted brotherhood.

Critical writing is equivalent to discussion at meetings. That is usually allowed and is sometimes as liberally provided for as are formal contributions themselves. A meeting at which discussion is not permitted is generally regarded as unsatisfactory, and the parallel situation in publication is equally so.

Even if other disciplines reject them, science should preserve and encourage its critics. A true scientist is a born sceptic, so why after retaining that quality long enough to make progress in science should he discard it? Scepticism, wholesome doubt, is among his most useful tools and its manifestations in a critic should be welcomed, not condemned. Humanity tends toward mob psychology, but the scientist should remain himself, poised, observant, critical of all things. To become one of a mob is to desert science. Suppression of criticism, rooted in the fatally easy preference for ease and freedom from every irritation or annoyance, is such a desertion and is, in the present state of philosophy, desertion in the face of the enemy.

BOOKS ON SCIENCE FOR LAYMEN

PERSONAL PROBLEMS OF ILLNESS[1]

ONE of the best things about Dr. G. Canby Robinson's book is its title. The emphasis upon "The Patient as a Person" is one that needs to be made over and over again in these days of microscopes, Wassermann tests and Roentgen rays.

This book is a later version of the social service studies made first by Dr. Richard Cabot and given national stature at the Massachusetts General Hospital. It is made up of several hundred detailed case histories classified in accordance with symptoms or diseases and analyzed from the standpoint of diagnosis and treatment in relationship to environment. It becomes an up-to-date analysis of medical social service. It presents in a detailed way those human problems that are a part of every illness.

It is fortunate that Dr. Robinson is wise enough to emphasize the significance of personal inadequacies in the care of those who are apt to become clinical patients in our various medical centers. Personal inadequacy, together with faulty personal habits, creates, for many who are unable to provide care for themselves during illness, as great or greater problems than lack of economic protection.

The book brings out in a very thoughtful way the tendency of the physician to think in terms of disease processes and to fail to recognize the rather high percentage of neurosis in many patients with organic ailments. This is a distinct handicap which can be corrected in part through an adequate social service.

In discussing the changes that have taken place in medical practice the author brings out the reaction of the physician associated with clinics, who has to obtain scientific satisfaction for his achievements rather than those affectionate and satisfying relations experienced by the family doctor in simpler days.

If such books as this one are brought to the attention of the medical student, the young physician and the social worker we can expect that there will develop a better mutual understanding on the part of the physician and the various associates who have been brought in to help him in his care of the sick. This will all be to the benefit of the patient. As. Dr. Robinson states, human nature is such that in chronic diseases the doctor is usually not consulted until the patient can no longer maintain social efficiency in the home or at work or in the field of recreation. When this is combined with inadequate economic resources and with ignorance as to most diseases it makes necessary the group assistance required by the ordinary clinical and hospital patient.

Since the patient must live with himself for twenty-four hours every day and the physician sees him for but a brief period, such a study as the author has made is sure to show the physician much more that he can do than to diagnose and prescribe.

RAY LYMAN WILBUR, M.D.

[1] *The Patient as a Person.* By G. Canby Robinson, M.D. xiv + 423 pp. $3.00. 1939. The Commonwealth Fund.

THE WORLD OF CREATIVE PHYSICS[1]

THE main reason why any intelligent person should consider reading Dr. Harrison's book, "Atoms in Action," is that it is really the only good book available which tells what the science of physics *does* rather than *is*. It contains the practical answers to the natural question of any non-physicist: "How does the science of physics directly affect me?" The philosophy and the theory of physics are subordinated in this book, and some of

[1] *Atoms in Action.* By George Russell Harrison. Illustrated. x + 370 pp. $3.50. 1939. Morrow and Company.

the worldly products and everyday rewards of this resourceful and advancing science are exhibited. It is the purpose of the book to do this.

In carrying out his purpose, the author has not neglected the classic example of physics as the parent of the entire electrical industry nor other examples like it. His emphasis, however, is on the recent, the present and the certain to come. This makes interesting as well as informative reading—interesting largely because the author is a gifted writer, informative because of the wealth of his subject and because he has well selected and balanced the topics he covers. The author stands like a farmer "looking his meadows o'er," with pleasure, no doubt, at their pleasant and wholesome appearance, but primarily with an appraising eye to the harvest therefrom.

The chapters are somewhat romantically titled, *e.g.*, "Sound Rides the Wire," "Glass—More Precious than Rubies," "The Ransomed Electron," "The Capture of Melody," "Man Climbs the Winds" and others. We can not regard such titles as inappropriate, however, if we admit that there is romance in the birth and growth of such industries as communication and air transportation, to mention only two. These are only two far-flung great industries founded on physics, two among others of even greater importance. Dr. Harrison's book gives a carefully checked, non-technical account of the physical basis of wire and wireless communication, steam, hydraulic and electric power, artificial illumination, the recording of sounds and action, transportation by land, sea and air, the forecast of weather, the use of raw materials, the production and preservation of foods, the correction of seeing and hearing, the preservation of health and the treatment of disease. This is a partial list only.

To cite an example, the chapter, "When Physics Goes Farming" refers to a farm as "a packaging establishment where energy from the sun is bottled up in the molecules of matter and stored for future use." Later, "the great primary problems of farming, apart from fertility, involve investigating and controlling temperature, light intensity, soil mechanics, and water application and disposal, all of which are problems of physics and the technology which springs from physical science." This five to ten billion dollar industry every day uses more power, heat and light from heat engines and electrical generators, more control over natural growing conditions, better storage of products, faster and safer transportation to market, better methods of soil conservation and more powerful methods of combatting pests. The farmer finds it possible to grow commercially a greater variety of plant species and, in fact, new species have been artificially created. In all these aspects the science of physics has played a fundamental rôle.

No chapter is more revealing than "The Doctor and the Physicist," for even though we are familiar with the fact that advances in science have enabled the saving of countless lives, we do not recall often enough the careful and painstaking use of instruments and laboratory devices which, in the hands of the medical profession, are the agents of this accomplishment. In "Atoms in Action," Dr. Harrison points to the x-ray, the microscope, natural and artificial radioactive substances, infra-red rays, the electric surgical knife and hundreds of gadgets for diagnosis and therapy.

If there is any single conclusion to be drawn from the evidence set forth in "Atoms in Action" it is, in Dr. Harrison's words, that "Man holds within his hands the power to make the world virtually what he will."

HENRY A. BARTON

SCIENTIFIC HUMANISM[1]

THIS remarkable book was first published in the United States by Covici-

[1] *Man the Slave and Master.* By Mark Graubard. x + 366 pp. London: 10s. 6d. 1939. J. M. Dent and Sons. (New York: $3.50. 1938. Covici-Friede.)

Friede of New York in 1938. Unhappily, the American publishers were forced to retire from the publishing field shortly after the publication of Dr. Graubard's book, and it is no doubt owing to this cause that the book has not, in this country, reached as wide an audience as it deserves. The English edition of the book, which is here reviewed, represents a revised and rewritten version of the American edition, and is to be regarded as a second edition which supersedes the American edition and which is, indeed, superior to it.

In recent years there have been a number of attempts to integrate and coordinate the basic principles of general biology and its branches with the processes of man's social life, so that such relationships as exist between these too long divorced "universes" might be better understood. Unfortunately, the advocates of understanding have too often found themselves in the position of a barrister who has been briefed to plead a case without having been supplied with the evidence necessary to plead it. The material witnesses have generally been most recalcitrant, and all that has been effected has been a reconciliation between the two parties, dramatic rather than convincing, speculative rather than sound, demonstrative rather than demonstrated. The sad fact is that the case has usually gone astray because the advocates have been no better equipped than most sophists have ever been, and have lacked a really profound understanding of the laws, principles and precedents with which it is necessary to be familiar before one can place the proper facts in their proper relations to one another, and so build up a solid case and perform a harmonic integration of them. In the present instance it is our pleasant task to have to record that it is Dr. Graubard's distinctive achievement to have combined in himself the qualities of an acute and brilliant mind, which has undergone a rigorous training and discipline in several distinct sciences, and in each of which he has done distinguished work, namely, in biology, biochemistry, genetics, endocrinology and cultural anthropology. Dr. Graubard may perhaps protest that he has done little, if anything, in the field of cultural anthropology to merit such praise. But in this connection it may at once be said that the reference is to Dr. Graubard's achievement in the present work, for in the considered opinion of the reviewer, this achievement constitutes a far greater and vastly more important contribution towards an understanding of the fundamental principles of cultural anthropology than anything that was ever achieved by Sir James Frazer, of "The Golden Bough," and Edward Westermarck, of "The History of Human Marriage," two of the best-known workers and their works in this field. These men were fact-collectors, not integrators, and their rather eclectic methods do not appeal to modern anthropologists. But however good one's methodology may be, it is not enough to master the methods and some of the facts of several sciences, if one is to bring them constructively to bear upon the solution of socio-biological problems. In addition one must possess the rare ability to discern the relations which exist between the manifold aspects of the various fields of activity and of knowledge involved; in brief, one must possess insight. As any one who reads this book will soon discover, not only is the author unusually well equipped in the fundamental biological sciences, but he is also extremely well endowed with the insight of the great scientist. This is a good augury for the task he has set himself of correlating some of the basic principles of physiology, embryology, heredity, biologic, cultural and social evolution, and of indicating the benefits that knowledge of these principles brings to the solution of problems of race, eugenics, art, social progress,

democracy, habit, custom, moral and ethical ideals, and many other important matters that are of vital significance for the present as well as for the future happiness and development of mankind.

Dr. Graubard is a scientific humanist, and his party and his creed are combined in the single purpose of the welfare of the human species as a whole. Not humanity in the abstract, or as Dostoievski used to say, by the book, but the practical immediate material and cultural welfare of every individual. By the application of scientific methods and scientific principles to the education and the government of men in democratically organized societies—and Dr. Graubard points out that scientific humanism is possible only in democratic communities—Dr. Graubard believes that the welfare of man can be unequivocally achieved.

Dr. Graubard is no idle visionary—the true visionary can have no room for visions—nor is he, as Lancelot Hogben says of him, an exponent of a "robust materialism." Indeed, this precisely is what Dr. Graubard is not, for, like Jacques Loeb, the clear motive behind his work is of a profoundly spiritual content, and as he writes himself in his fine concluding chapter, "The Meaning of Scientific Humanism," "Man never lived by bread alone, difficult as the struggle for it was. He always had a spiritual craving which apparently yielded great emotional satisfaction and enriched his life.

"This craving expressed itself in mystic and religious beliefs but also included the desire for social justice. In fact, the mystical ideas of religion were symbols of social relations, aims and feelings. The elimination of this deep-rooted spiritual craving can only harm man. Science has dispelled the magical components of religion, but it can not destroy the social elements. These give our lives too much meaning, in fact, they give meaning and justification to science. Without the guidance of spiritual feelings life will become crude and pointless.

"Scientific humanism recognizes the spiritual desires of man and gives them concrete expression and guidance. It will be more gratifying than *past* philosophies because it is based on a knowledge of reality" (p. 353).

And that is the keynote of this closely reasoned book. The material facts of man's biological and social development are masterfully set out, and their manifold relations are discussed and illuminated always with reference to their meaning and utilization for the good of man, here and now. If man can not live by bread alone, neither can he live by science alone, *that* has become abundantly clear, for whether his spiritual cravings are of internal or external origin, they are always with him, and any philosophy of crass materialism which refuses them recognition must founder upon that inevitable rock. It is the great tragedy of our age that we have been too long avoiding the recognition due to the irrepressible spiritual qualities with which we are all endowed. These qualities must, and do, find expression, but if their existence is ignored, they are likely to find expression in confused, emotional, undisciplined, mystical, prejudiced ways. Scientific humanism can supply the guidance which the spiritual needs of man require. Facts are indispensable, but they are not enough. What is required is the humanely cultivated attitude of mind which will enable the individual to evaluate facts critically and humanely; for what, in the ultimate analysis, is the use of any scientifically established fact, unless it be humanely understood and humanely used? Perhaps the present state of the world is the best answer? Unquestionably the best exposition of what man has been, what he now is, and of the potentialities he possesses for being, is to be found in Dr. Graubard's brilliant book.

M. F. Ashley-Montagu

AMERICAN ASSOCIATION MEETING PLACE, JUNE 17–22

THE CAMPUS OF THE UNIVERSITY OF WASHINGTON. ON SHORE ACROSS THE BAY FROM THE LEFT IS THE SHOWBOAT THEATER AND THE OCEANOGRAPHIC LABORATORIES. BETWEEN THOSE STRUCTURES AND SLIGHTLY TO THE REAR IS HYDRAULICS LABORATORY. IN THE CENTER IS DANIEL BAGLEY HALL; IN RIGHT CENTER BEYOND THE UNIVERSITY GOLF COURSE IS ANDERSON HALL. OTHER BUILDINGS OF THE 582-ACRE CAMPUS ARE GROUPED IN THE BACKGROUND.

THE PROGRESS OF SCIENCE

MEETING OF SCIENTISTS OF THE AMERICAS

THE Eighth American Scientific Congress was held in Washington, D. C., from May 10 to 18. Though primarily scientific, the congress aimed to integrate science in the Americas with the social and political life of the people, for science can no longer be considered as separate and distinct from other forms of human activity. In our modern civilization science in one form or another enters into every element of our social structure.

Man as he used to be, as he is to-day and as he is to be in the future; his social organization, welfare and activities of every kind, and especially man in his relation to America and to other Americans—this was the broad subject that occupied the attention of the congress.

The formal opening of the congress on the evening of May 10 was featured by a stirring and memorable address by President Roosevelt, in which he referred feelingly to the invasion of Belgium, The Netherlands and Luxembourg, which had occurred a few hours before. He acknowledged with appreciation the great achievements of science in the extension and development of modern civilization, and said that the objectives toward which science is striving are closer and more peaceful relations between all nations through the spirit of cooperation and the interchange of knowledge. He deprecated the idea that science is responsible for the present "attacks on civilization which are in progress elsewhere," remarking that "The great achievements of science and even of art can be used to destroy as well as to create; they are only instruments by which men try to do the things they most want to do."

President Roosevelt's words made it very clear that although the participants in the congress were the twenty-one American republics only, the people of these American republics no longer can regard themselves as independent of, and insulated from, affairs in other portions of the world. Neither can science be regarded as distinct and apart from other forms of human activity.

Of most immediate interest to every one are the sciences grouped under public health and medicine. These in recent years have attracted much attention throughout the Americas. There were 119 papers presented in this—much the largest—section.

In order to keep track of health and other conditions affecting populations it is necessary to have at hand accurate and up-to-date statistical information. Throughout the Americas this is recognized as of vital importance. In the Section of Statistics there were 71 papers read by statistical experts from all the twenty-one American republics.

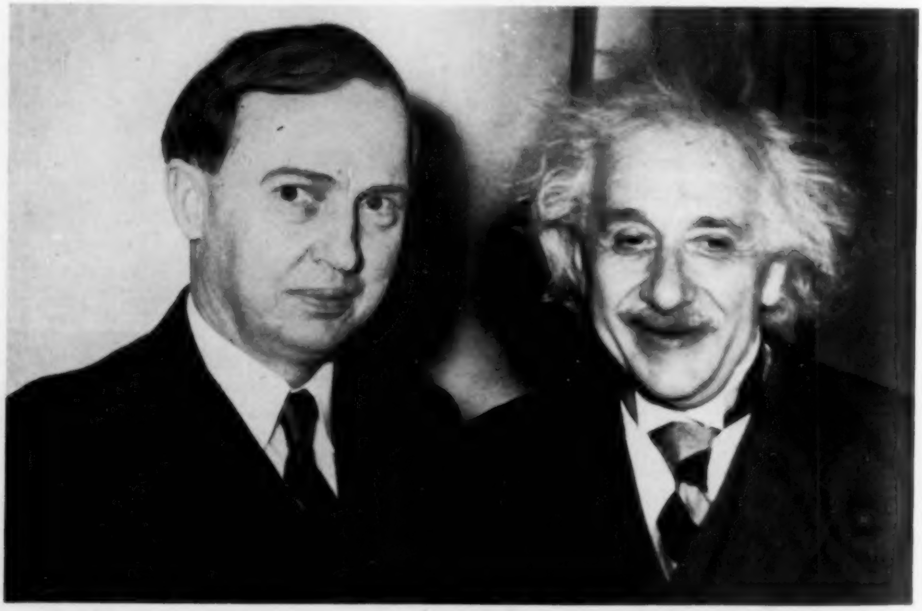
Although public health attracted most attention at the congress, the interrelations of the people, as individuals and collectively, and their relations to local and general conditions—included under sociology and economics—were discussed in numerous papers. These subjects were treated both from the point of view

THE HONORABLE SUMNER WELLES
UNDER SECRETARY OF STATE UNDER WHOSE PRESIDENCY THE CONGRESS WAS HELD.

of the several national units and from the point of view of a closer unification of the American republics.

A closer unification of the American republics envisions a greater uniformity in legal systems and in legal procedure than exists at present. There were 78 papers dealing with various aspects of international law, public law and jurisprudence. During the sessions the American Society of International Law, the American Law Institute and the Section of International and Comparative Law of the American Bar Association met in Washington, their programs to a large extent interdigitating with those of this section.

Education plays a large part in fitting individuals to take their proper place in the affairs of the communities in which they live. Education therefore occupied a prominent place in the proceedings of the congress. There were 61 contributions on this subject.



DR. HARLOW SHAPLEY AND PROFESSOR ALBERT EINSTEIN
WHOSE ADDRESSES CONSTITUTED A SPECIAL SESSION OF THE SECTION OF THE PHYSICAL AND CHEMICAL SCIENCES. DR. SHAPLEY SPOKE ON "HARVARD-PERUVIAN RESEARCHES ON GALAXIES"; PROFESSOR EINSTEIN SPOKE ON "CONSIDERATIONS CONCERNING THE FUNDAMENTS OF THEORETICAL PHYSICS."

The history and geography of a region determine the background and traditions of the people, their social structure and how they are supported. In this section there were 64 papers, dealing mainly with Latin America.

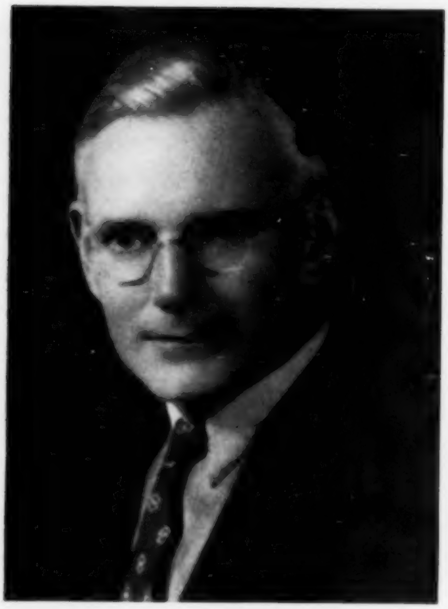
People in order to support themselves must make use of the natural resources of the regions in which they live, and because people must eat, the development and the conservation of agricultural resources is of first importance. These subjects were treated in 42 contributions.

Agricultural resources are supplemented by mineral resources, which were discussed in the Section of Geology. In this section there were presented 57 papers, covering practically all phases of the subject.

The proper utilization of the natural resources of any region is dependent upon proper appliances and methods for the cultivation of the land, for the extraction of minerals from the earth, for transportation and communication and for converting raw materials into fin-

DR. WARREN KELCHNER
CHIEF OF THE DIVISION OF INTERNATIONAL CONFERENCES OF THE DEPARTMENT OF STATE WHO SERVED AS EXECUTIVE VICE-PRESIDENT OF THE CONGRESS.

FROM THE HISTORICAL MAP COLLECTION OF THE LIBRARY OF CONGRESS
COLONEL LEWIS MARTIN, OF THE LIBRARY OF CONGRESS, TRACES THE LINE OF ISLANDS LINKING NORTH AND SOUTH AMERICA ON A GLOBE PLACED ON EXHIBITION.



DR. ALEXANDER WETMORE
ASSISTANT SECRETARY OF THE SMITHSONIAN INSTITUTION WHO WAS SECRETARY-GENERAL OF THE CONGRESS.

ished products of all descriptions. Here physics and chemistry play their part. In the Section of Physical and Chemical Sciences there were 62 papers. In all branches of science it is necessary to look to the future—to outline general plans or "laws" by means of which a multitude of apparently disconnected facts may be brought into correlation and thus take their proper place in a unified whole. This theoretical aspect of science has been especially developed in physics and in chemistry. Most important of the contributions under this heading was an address by Professor Albert Einstein on "Considerations Concerning the Fundaments of Theoretical Physics."

In the Section of Biological Sciences there were 79 contributions on a very wide range of topics in zoology and botany, and in the Section of Anthropological Sciences there were 77 papers covering all aspects of general archeology, psychology, general ethnology, physical anthropology, linguistics, folklore and the original peopling of America.

The scientific program was supplemented by an extensive social program. On Monday, May 20, the delegates visited Philadelphia as guests of the American Philosophical Society, the oldest of American scientific societies, founded by Benjamin Franklin, and on the day following they visited the New York World's Fair, of which they were the guests throughout the day.

The total registration at the congress was 1,750, but the attendance was probably nearly or quite twice that figure. There were 295 delegates from Latin America and 1,455 from the United States.

The congress was closed by President Sumner Welles with an able and vigorous address that followed the same lines as President Roosevelt's address of welcome. But he closed with a note of optimism:

"I believe—as firmly as I believe that the sun will rise once more to-morrow—that the present menace to civilization will pass and that the day will come when the now destructive forces of evil which men themselves have created will be vanquished."

AUSTIN H. CLARK

MEDALISTS OF THE NATIONAL ACADEMY OF SCIENCES

AN individual who renders unusual service in a special field of human endeavor deserves recognition and commendation from his fellow man. In the field of science appreciation of an important contribution to knowledge is expressed by the bestowal of an appropriate honor on the one responsible for the accomplishment. Universities confer honorary degrees; scientific societies award medals and honoraria in recognition of meritorious original work in science.

The National Academy of Sciences

awards, as a rule, four medals each year, chiefly in the fields of astronomy and astrophysics, of oceanography, of paleontology and of public welfare. Many branches of science are unfortunately not mentioned in the deeds of gift of the eleven funds entrusted to the academy for medals awards; because of this restriction, workers in these fields of research are not eligible for awards. Provision to remedy this situation will probably be made in the course of time by gifts made to the academy for the establishment of additional trust funds.

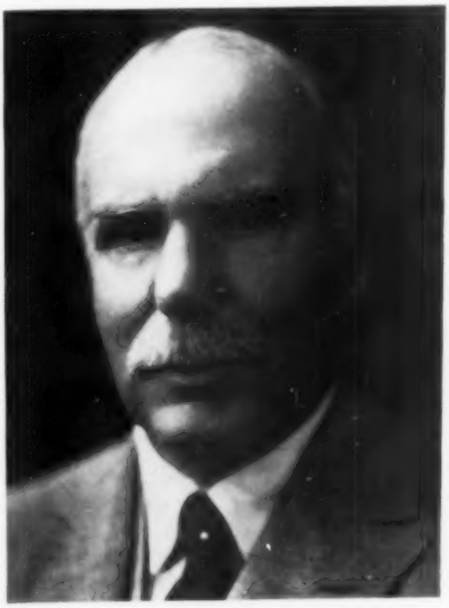
At the seventy-seventh annual meeting of the academy, held in April, three medals were awarded: the Agassiz Medal for Oceanography, to Frank Rattray Lillie; the Public Welfare Medal, to John Edgar Hoover, and the Charles Doolittle Walcott Medal and Honorarium to A. H. Westergaard.

In his presentation speech recommending the award of the Agassiz Medal, Dr. E. G. Conklin stated that:

> In these times of exaggerated nationalism it is fortunate that we can still emphasize the internationalism of science. The Murray Fund of the National Academy of Sciences is peculiarly international in its foundation and purpose. It was established in 1911 by Sir John Murray, Canadian by birth, Scot by adoption, internationalist in science, to honor the memory of Alexander Agassiz, Swiss-born American, cosmopolitan as the ocean in his research work. Of the seventeen awards of the Agassiz Medal which have been made hitherto, fourteen were given to foreign oceanographers, three to American. Of the foreign awards, five went to Norwegians, two to Swedes, two to Danes, two to Britons, and one each to oceanographers of Holland, Germany, and Monaco.
>
> The eighteenth award of this medal is to one who is a Canadian by birth, American by adoption and an internationalist in his sympathies and services, Frank Rattray Lillie, thirteenth President of the National Academy of Sciences. For twenty-six years he was Director of the Marine Biological Laboratory at Woods Hole, Massachusetts, and he was president of that institution from 1926 to 1939. . . .
>
> For his important researches and his wise leadership in marine biology, for his enduring contributions to the science of oceanography in the founding and endowing of the Woods Hole Oceanographic Institution, for his modest but effective leadership in causing this country to assume its share in a world-wide program of oceanographic research, the Committee on the Murray Fund presents to you, Mr. President, for the eighteenth award of the Agassiz Medal, Frank Rattray Lillie.

In response Dr. Lillie expressed pleasure in receiving the award but wished personally to emphasize the fact that he did so "in a representative rather than in a personal capacity. The accomplishments have been, indeed, the work of many minds and hearts." In his address he sketched the early development of the study of oceanography in this country and abroad and of the gradually increasing interest taken in it because of its scientific and economic possibilities.

In the presentation address for the Public Welfare Medal, Dr. Max Mason, member of the committee on the Marcellus Hartley Fund from which the award was made, stated that:



DR. FRANK R. LILLIE

DR. J. EDGAR HOOVER

By temperament, by tradition, and by resolution, the people of the United States are devoted to the ideal of human freedom and human dignity. This ideal may be threatened from without our country or from within, and the dictum that eternal vigilance is the price of liberty applies as well in the one case as in the other.

To maintain law and order in our society is more than to preserve property or safeguard life. It is to maintain a social framework in which the good life may be lived; to free men from the threat of vicious cruelty of the criminally minded. Respect for government itself grows as governmental agencies succeed in this vital work of the preservation of freedom.

To-night the National Academy of Sciences presents the Marcellus Hartley Medal for great public service to John Edgar Hoover, Director of the Federal Bureau of Investigation of the United States Department of Justice. . . .

Hoover brought to this great agency of American law enforcement a high idealism, great organizing ability, and a trained mind. He insisted at once on freedom in making appointments to his staff from any political pressure, and rapidly raised to a high level the requirements in character and training for the personnel of the Bureau. Brains and character—not brawn—became the word. College graduates—not political castoffs—became his special agents. Specialized functions were organized and raised to a high efficiency. Through this organization the dignity and ability of a profession are being brought to a level consistent with its social importance. . . .

In spirit and performance the work of John Edgar Hoover has exemplified the scientific way of life. To the many formal expressions of appreciation which he has received we add to-night that of the National Academy of Sciences for great public service performed in a scientific manner and by the aid of science.

On receiving the medal, Mr. Hoover expressed his appreciation of the award and said in part:

The development of science in the field of crime detection has not been without its annoying interruptions. With the inauguration of the Technical Laboratory of the FBI in 1932 came ridicule and scorn. On more than one occasion our men have been ironically depicted as impractical young men pursuing criminals while clad in academic gowns carrying magnifying glasses.

The experiences of the past few years have demonstrated conclusively that science protects the innocent and convicts the guilty. Surely a record of over 95 per cent. convictions in all cases tried in court after investigation by Special Agents of the FBI is a tribute to the place of science in the world of law enforcement. There can be no question that we have been justified in investing the taxpayers' money in the equipping and maintenance of a Scientific Crime Detection Laboratory that is regarded as a model throughout the world, when over a period of years every dollar spent in the cost of operations of the FBI has resulted in a dividend of over six dollars for the taxpayers of America.

If the record of the Federal Bureau of Investigation means anything, it has proven that science is the greatest weapon next to intelligent, well-trained personnel that society possesses to cope with the criminal. No longer do courts question the validity of the qualified scientific expert.

Thus it is with pardonable pride that I accept the Public Welfare Medal of the National Academy of Sciences for and in behalf of the entire personnel of the organization that I have been proud to head for the past sixteen years; for ours is truly a "We" organization and not an "I" organization, and no finer recognition could be bestowed upon the FBI for its part in furthering science in the detection of crime than this award. May we regard the past as a period of introduction of science into the profession of law enforcement which will blossom and bear

fruit in the years to come in every community in America, in order that justice may ever remain triumphant.

On behalf of the Board of Trustees of the Charles Doolittle Walcott Fund of which he is a member, Dr. C. G. Abbot, secretary of the Smithsonian Institution, made the presentation address and referred to the purpose for which the medal and honorarium were primarily established, namely, to encourage work on Cambrian and Precambrian forms of life. In the words of Dr. Abbot:

The committee has unanimously recommended the award this year to Dr. A. H. Westergaard of the Swedish Geological Society of Stockholm, for his eminent researches on the stratigraphy and paleontology of the Cambrian formations of Sweden.

Westergaard's major work, published in 1922, "is a complete description of the trilobite species of which about 28 were new. The beds of Norway and Denmark are correlated with the Swedish formations." Now a man of 60 years, Westergaard is still active in the Cambrian field, having published frequently and regularly right up to the present time. His latest publication, in 1938, describes a deep boring through the Cambro-Silurian and File Haidar, in Gotland, and contains accounts of Lower and Middle Cambrian deposits therein and of the contained faunas.

In view of Dr. Westergaard's valuable contributions to both stratigraphy and paleontology of the Cambrian period, and his continued zeal in these investigations, the committee of award has much pleasure in recommending that the Charles Doolittle Walcott Medal and Honorarium be presented to him.

DR. A. H. WESTERGAARD

The medal and accompanying honorarium were received for Dr. Westergaard by the Minister of Sweden, the Honorable W. Bostrom, for transmission to him through diplomatic channels.

F. E. Wright,
Home Secretary

THE IMPERIAL VALLEY EARTHQUAKE

On May 18, the people of the United States were again reminded that there are regions within its borders where severe and even destructive earthquakes may be expected, and it was also demonstrated that after a severe earthquake there is no definite period of immunity. These are among the lessons of the Imperial Valley, California, earthquake occurring on that date, which, although not among the great earthquakes of the United States, stands perhaps fifth in property damage. Field observations by F. P. Ulrich, of the U. S. Coast and Geodetic Survey, who is in immediate charge of the seismological work of the survey in California and other western states, indicated that at Brawley, while perhaps 50 per cent. of the business buildings were damaged, newer residences suffered only slight damage. Local engineers estimate that the total damage may reach \$5,000,000. At Imperial, damage in the business district was very heavy. At El Centro, the damage was moderate and at Calexico, rather light. At Holtville, only

STRONG-MOTION SEISMOGRAPH RECORD OF THE IMPERIAL VALLEY EARTHQUAKE

OBTAINED BY THE COAST AND GEODETIC SURVEY AT EL CENTRO, CALIFORNIA. THIS TYPE OF INSTRUMENT OPERATES ONLY WHEN STRONG EARTHQUAKE MOTION STARTS IT. THE RECORD SHOWS THE ACCELERATION (SOMETIMES CALLED "FORCE") OF THE GROUND MOTION IN TWO HORIZONTAL DIRECTIONS AND THE VERTICAL. FROM TOP TO BOTTOM THE THREE TRACES SHOW MOTION IN THE VERTICAL, NORTH-SOUTH AND EAST-WEST DIRECTIONS, RESPECTIVELY.

a few chimneys and walls were thrown down.

One of the serious effects in this region, which depends upon irrigation, was damage to water supply. This included breaks in the canal on the Mexican side of the border and the collapse of the city water tank of 50,000 gallons at Holtville. Engineers are greatly interested in damage to the necessary structure related to water supply, including dams and embankments and also tanks, and the damage to these will be carefully studied.

Those interested in the construction of tanks have given much thought to the matter since the Long Beach earthquake of March 10, 1933. Professor A. C. Ruge, of the Massachusetts Institute of Technology, has studied the design of tanks to resist earthquake damage chiefly through studies of the behavior of a model which was tested on a shaking platform which reproduced the motions of the Long Beach earthquake as obtained from records of the Coast and Geodetic Survey. Undoubtedly, a new impetus will be given to such studies.

The geological conditions in the Imperial Valley region are an important factor. There are very deep sediments overlying the rock, and the San Andreas and other faults branching from it which can be well located further north are indicated in the fault maps by broken lines, since they can not be directly traced. In most of the earthquakes in this region the surface changes have been almost undetectable, but on this occasion there was a slip of 12 feet in the northwest-southeast direction at a place near Highway 98. The Coast and Geodetic Survey has executed triangulation and leveling in this region and these observations would have to be repeated in order to detect other changes which are not visible. It is expected that an instrumental study of the earthquake will be undertaken by the Seismological Laboratory of the California Institute of Technology at Pasadena.

Fortunately, an accelerograph for the

recording of strong earthquake motions which the Coast and Geodetic Survey had in operation at El Centro (at the Terminal Station of the Southern Sierra Power Company) gave an excellent record, which is reproduced in Fig. 1, and there were a number of records at other points in southern California. This record shows the highest acceleration which has yet been measured, but the record will have to be carefully analyzed before definite statements can be made. Strong-motion instruments were set in operation in both the San Diego and the Los Angeles regions. There are now 51 instruments in operation in California, four in Montana, one in Utah, four in Nevada and one in Panama Canal Zone. All but three (Lake Mead region, U. S. Bureau of Reclamation) are owned and operated by the Coast and Geodetic Survey, with considerable cooperation. With this distribution, recording is assured of the motions of practically all destructive earthquakes that may occur in California and in the other localities mentioned.

Some of these instruments have such a wide range that they are able to record the accelerations of the most severe earthquakes. That at El Centro, set up in 1932, was an earlier type and for a very short period the record was off the sheet, though from a practical view-point there is no serious loss of record. With a few exceptions the instruments are designed to give the acceleration, though the periods and duration of earth motions can be obtained from them directly and the displacement, or to-and-fro motion of the ground, by integration. Any or all of these elements may be concerned in destruction, and one of the valuable features of these records is that by a study of the destruction immediately after it occurs it may be related to the actual earth-movements. This has been possible only for the last seven years.

The violent motions shown in the record are in part due to the intensity of the earthquake but also in part to the fact that the surface of thick sediments is put into violent motion. The same phenomena were observed in the 1906 California earthquake and in the Mexican earthquake south of the Imperial Valley on December 30, 1934. There is a curious paradox in regard to these violent motions, in that while the actual motions of sediments are more violent, there seems to be a cushioning effect in the case

EARTHQUAKE DAMAGE TO HOTEL IN EL CENTRO IN CENTRAL CALIFORNIA
A MAN WAS KILLED WHEN THE UPPER PART OF THE BRICK WALL FELL INTO THE STREET.

FAULT JUST WEST OF ALAMO RIVER BRIDGE
ON HIGHWAY NO. 98. THE SHIFT WAS EIGHT FEET IN AN EAST-WEST DIRECTION AND THREE FEET VERTICALLY.

of strong buildings. This problem has not yet been solved by engineers and seismologists, but it has an important bearing on safety measures.

Most of the cities and towns are comparatively small and there are few tall buildings. The buildings that have chiefly suffered are not more than a few stories in height; therefore, it is a matter of great interest to the average citizen to find out what safety measures should be taken. It seems probable that application of the California code of building construction in reconstruction, both as to material and workmanship, will greatly reduce future damage. Proximity of weak and strong buildings accounts for much destruction in present-day earthquakes.

Reconstruction is closely related to the future probability of earthquakes. While prediction of earthquake in time and place is now impossible and likely to remain so, the seismic history of a region is a good guide to what may be expected. The first historic earthquake which may be ascribed to the Imperial Valley was in 1843. Then there were no others listed till 1903, though the Southern Pacific Railroad has traversed this region since the early 1880's and its personnel would have reported any earthquakes of importance. From 1903 to 1940 there have been fourteen destructive and near-destructive earthquakes, of which three were strong aftershocks. The principal occurrences were in 1915 and 1927 with serious destruction in a number of towns; and 1930 with strong local damage in Westmoreland and Brawley, in two distinct shocks. Some of the shocks mentioned were in Mexico but were near enough to cause damage. With such an earthquake record it is essential that provisions for resistance to earthquake damage should be made in the case of all reconstruction and new construction in this entire section of the country.

N. H. Heck

A PALEONTOLOGICAL EXPEDITION INTO THE SOUTH DAKOTA BADLANDS

A joint paleontological expedition of the National Geographic Society and the South Dakota State School of Mines will work in the Badlands of South Dakota during the coming summer in search of fossil remains of mammals, especially those of New World types of rhinoceros. The expedition, just announced by Dr. Gilbert Grosvenor, president of the National Geographic Society, will begin its field work early in June. Dr. Joseph P. Connolly, president of the School of

Mines, will be in charge, assisted by James D. Bump, curator of the museum of the school.

The excavations will be made in southwestern South Dakota in the fantastically eroded badlands area between the Cheyenne and White Rivers, southeast of Rapid City. Although it is expected that skeletal remains of numerous large and small mammals will be found, a special search will be made for fossil bones of titanothere (literally "giant beast"), other types of rhinoceros and protoceras. The titanothere was a sort of elephantine rhinoceros, the largest of them as much as nine feet high at the shoulder. Buried in the same beds of rock with these giants were much smaller rhinoceros-like creatures. Both these types of animals had relatives in the Old World.

The protoceras, as reconstructed, was an odd beast, remotely related to deer and antelope. The male, about the height of a sheep, had six horns or knobs on his head, one pair of them far down on his slender muzzle. Other unusual features were a pair of long slender tusks, rare among cud-chewing animals, front feet with four toes and hind feet with only two. No member of the protoceras family has been discovered outside of North America.

It is estimated that the beasts whose fossil remains the expedition hopes to find lived in the Badlands area, then a grass-covered region of rolling plains, about thirty million years ago. Through changes not entirely clear to geologists, large quantities of eroded materials and volcanic ash from an unknown source were deposited on the old grassy plains, covering skeletons of some of the creatures that inhabited them.

Erosion during the last ten thousand years or more, while creating the weird, deeply carved terrain of the Badlands, has exposed some of the buried bones and has disclosed the region to be a rich treasure house for paleontologists. Petrified skeletons of many types of vertebrate animals have been found there during the last three quarters of a century. But among these only a few complete

Photograph by National Geographic Society

A TYPICAL VIEW OF THE BADLANDS BETWEEN THE CHEYENNE AND WHITE RIVERS

Photograph by National Geographic Society
A PORTION OF THE SOUTH DAKOTA BADLANDS SOUTHEAST OF RAPID CITY

skeletons of titanothere, protoceras and small rhinoceroses have been recovered. The expedition's chief aim will be to bridge this gap in scientific knowledge of the region.

The South Dakota Badlands were relatively inaccessible until a decade ago. Within the past few years some of the most scenic and picturesque portions of the eroded area have been set aside by the United States Government as the Badlands National Monument. Excellent automobile roads have been built through the reservation. During the year 1939 visitors numbered 205,100, the greatest number to visit any National Monument west of the Mississippi River.

McFall Kerbey

RECENT PROGRESS IN THE STUDY OF BLOOD CLOTTING

Recent work on blood clotting has aroused the interest both of biologists and of practicing physicians. Present view-points are based on the older physiological studies, which, in turn, were a gradual outgrowth of the "vitalistic" concepts of olden days. The clotting process is known to occur in two main stages. The clot itself is formed in the second stage by the transformation of a soluble protein, fibrinogen, into an insoluble protein, fibrin. The fibrin clots out in the form of innumerable interlacing threads which, in the aggregate, give the clot its rigidity.

The transformation of fibrinogen into fibrin in the second place is brought about by a ferment-like substance known as fibrin ferment or thrombin. Thrombin does not occur as such in circulating blood, otherwise clots would form within the vessels. Blood does, however, contain a proferment known as prothrombin. It is during the first stage of clotting that this proferment is converted into thrombin.

One of the recent developments concerns the varying ability of the body to manufacture prothrombin. For one thing, we have been able to show in our

own laboratory in Iowa City that the liver is concerned in the process. When this organ is seriously diseased the prothrombin content of the blood falls to abnormally low levels, and the individual bleeds excessively, even from tiny cuts and scratches.

More important, still, is the discovery of a new "coagulation vitamin," vitamin K, which the body needs in order to manufacture adequate amounts of prothrombin. This vitamin was discovered more or less incidentally in the midst of dietary studies made ten years ago on chicks by Dam of Copenhagen. It was later shown by Dam and by Almquist of California and by their colleagues that the new vitamin is abundantly present in many green vegetables, notably in spinach and alfalfa. The vitamin was finally extracted and purified and the chemical nature determined through their efforts and those of Doisy and his colleagues of St. Louis. It was likewise shown that a score or more of compounds could be produced which possess biological activity similar to the naturally occurring material. Almost without exception the active compounds were derivatives of 1,4-naphthoquinone.

Recent work indicates that simple dietary deficiency is rarely sufficient to cause a serious lack of vitamin K in man. However, there are conditions in which this vitamin is not properly absorbed from the intestine. The chief condition is one in which the intestine fails to obtain the bile which normally passes through the bile ducts into the upper portion of the small intestine. Bile is important because it aids in the absorption of oily materials, including vitamin K. A lack of bile occurs whenever the main bile duct is obstructed by gall stones or by tumor growths, causing the familiar clinical picture of obstructive jaundice.

That patients with obstructive jaundice can be cured of their bleeding tendency by administration of vitamin K was first shown by Drs. Warner, Brinkhous and myself, and by Butt, Snell and Osterberg at the Mayo Clinic. Since these studies were made, three years ago, numerous confirmatory reports have appeared, and vitamin K is now used routinely by great numbers of medical practitioners. Incidentally, it has been shown that vitamin K may be of value in the treatment of certain types of hemorrhage which appear at times in young infants. Some workers have suggested the wisdom of giving the treatment routinely to newborn infants, or to the mothers prior to delivery.

A second development which promises to be of considerable importance involves the isolation and purification of the clotting ferment, thrombin. Dr. Walter H. Seegers in our laboratory has improved upon the older technics, and recently he has obtained thrombin of such potency that one part of it will cause 20,000 parts of blood to clot solidly within one or two seconds. This is vastly more rapid than the spontaneous variety of clotting, which normally requires five or ten minutes.

Preliminary tests on animals and on man indicate that purified thrombin may be of great value in controlling certain types of bleeding at operation or from accidental wounds. The bleeding from large vessels can be checked quite well with ligatures, but in the case of true "bleeders," the bleeding often continues for hours from innumerable tiny vessels, and it is in such cases that thrombin promises to be of benefit. Thrombin has not yet been prepared on a commercial scale, however, and it is evident that many months will elapse before adequate amounts of thrombin can be obtained for the large-scale tests which must precede any attempt to place the product on the market.

A third development which has received much attention is in connection with certain naturally occurring prod-

ucts which inhibit clot formation. Somewhat over twenty years ago Howell and Holt of Baltimore described one such inhibitor, which they spoke of as "heparin," because it could be obtained from the liver. Other factors which inhibit clotting have been studied recently, and the possibility exists that some of them may be the cause of certain types of bleeding which still defy precise analyses.

In the meantime, workers in Toronto have made much progress in their efforts to purify heparin, and Dr. C. A. Best of that city has proposed giving heparin intravenously to prevent or to check the clotting which sometimes occurs within vessels of the living patient. Quite recently, surgeons had removed such clots in well-selected cases, and have employed heparin to prevent the clot from reforming during the process of healing.

Despite the progress in various fields, much still remains to be done. It is evident that there are at least four or five fundamentally different types of bleeders. Vitamin K is of benefit only in one specific group. The other types must still be treated by transfusion, or possibly by thrombin. It is to be hoped that the fundamental technics of chemistry, applied in the laboratory and in the clinic, will bring as much enlightenment in the next few years as they have in the recent past.

H. P. SMITH, M.D.

CIVILIAN SCIENTISTS IN GOVERNMENT SERVICE

THERE were on November 1 a total of 41,912 civilian scientists in the employ of the Federal Government, each receiving an annual salary of at least $2,000, of whom 40,200 were males and 1,712 were females. There were, in addition, 17,615 representatives of other professions, such as accountants, architects, lawyers and librarians.

Of the scientists, the engineers were the most numerous, with a total of 17,702. The next largest group was the economists, with 6,300 males and 300 females. The physicians and dentists stand high with 2,650, of whom only 50 are women, followed closely in numbers by 2,000 veterinarians. If the word *scientist* has been interpreted rather more liberally in the foregoing than is customary, we may note that there were on the list 3,200 agriculturalists and botanists, 1,230 physical scientists and geologists, 1,335 chemists and metallurgists, 780 statisticians and mathematicians, 640 zoologists and naturalists and 1,015 entomologists and husbandmen. One of the interesting groups is the 445 reporters and editors, or one for every 94 scientists, even with the liberal interpretation of the term used above.

From one point of view, the large number of civilian scientists and technicians employed by the Federal Government is a measure of the support the government is giving scientific work. From another point of view, the large number of these employees raises an important question of long-range policy, because control inevitably lies with financial support. As illustrative, but as yet quite exceptional, we may cite the engineering reports on the Passamaquoddy electric project and the proposed canal across Florida, which were in direct contradiction to reports that had more than once been made by similar authorities before these became government projects. In view of the fact that in various parts of the world political authority now decides what shall be taught respecting questions of science and history, we may well inquire whether the long future will confirm our present high opinion of our system of politically controlled public schools. As the history of civilizations goes our experience in public education is yet very short.

F. R. M.